SCIENCE IN WILDLAND WEED MANAGEMENT

DENVER, CO
APRIL 8-10, 1998

PROCEEDINGS

Table of Contents

CONTROL

RESTORATION

ORGANIZATIONAL STRATEGIES NEEDED FOR IMPROVED WEED MANAGEMENT

SUMMARY

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BLM Weed Page

National Weed Symposium

April 8-10, 1998

PROCEEDINGS

Statement by Secretary of the Interior Bruce Babbitt on Invasive Alien Species

April 8, 1998

The invasion of noxious alien species wreaks a level of havoc on America's environment and economy that is matched only by by damage caused by floods, earthquakes, mudslides, hurricanes, and wildfire. These aliens are quiet opportunists, spreading in a slow motion explosion.

Each year noxious weeds exact an ever-heavier toll: Farmers and ranchers spend more than $5 billion just for control. Losses to crop and rangeland productivity exceed $7 billion. Weeds infest 100 million acres in the U.S., spread at 14 percent per year, and -- on public lands -- consume 4,600 acres of wildlife habitat per day. They diminish or cause the extinction of native plants and animals, a third of all listed species. They homogenize the diversity of creation. They ignore borders and property lines. No place is immune.

Consider the damage done by purple loosetrife, a beautiful, seemingly harmless flower one might be pleased to find in a meadow. But not for long. For this species, found in 36 states, costs $45 million to manage.To bring this into a statewide perspective, consider that Florida spends $11 million each year to manage water hyacinth. Tropical soda apple, first reported in Florida, now covers 370,000 acres and costs the state $28 million.

In the past it was, again, much easier for an individual, a state, a federal agency to dismiss this invasion as someone else's problem. And so the weeds -- slowly, silently, almost invisibly, but steadily -- spread all around us until, literally encircled, we can no longer turn our backs on it. The invasion is now our problem. Our battle. Our enemy.

Conservative estimates count 2,000 alien plant species, 350 of which experts say are serious and dangerous invaders. Each day, new cargo ships arrive in American ports, and new shipments of tropical fish and plants are sold on the open global market. Some noxious weeds were introduced with the best of intentions, shipped to make a garden colorful, to dry up wetlands, to provide ground cover. Obviously, we cannot and should not shut down that global trade in an effort to grind the weed invasion to a halt.

What we can and must do is unite and prepare for that invasion both early and thoroughly. We can establish a responsive and comprehensive network, a network that will stop and someday even reverse

the spread of invasive alien weeds, a network that efficiently ***shares*** all human and economic resources rather than keep them working alone in isolation.

It must be a network forged by scientists and land managers, by local, state, and federal officials, by Eastern nurseries, Southern foresters, Midwestern farmers, Rocky mountain cattlemen and Western irrigation engineers.

Last June, the Vice President asked Secretary Glickman, Secretary Daley and I to prepare and action plan that establishes goals, and steps we can take to stop, control, and in some cases eradicate invasive aliens. It is a heavy task, but one big thing helps us: The invasion and spread of noxious alien weeds unites us. It unites across political, economic and property boundaries. It brings solidarity among opposing groups. It compels us to share strategic responses. It draws on our sense of values, calling on us to rise above our sometimes petty day-to-day concerns and disagreements. To restore health and stability.

To forge this continental network, we can draw from a deep and wide pool of resources. For there have been thousands of independent studies, documentation, research projects focused on a narrow, single tract. Scientists have spent their lives to prove weeds:

- Hybridize and swamp native species.
- Transmit disease, like fungi, that kill trees like the American chestnut and beech.
- Wipe out diversity, eliminates food, nesting and shelter for native wildlife.
- Alter fire regimes: melaleuca retards fire where it is needed; exotic grasses in Hawaii fuel fires that are not.

But despite all this extensive proof, there had not been a comprehensive account that puts all these pieces together, looking past borders and property lines, revealing the full, continental scope of the invasion. There was no national library to bring order and usefulness to such a vast, rare collection. Much of our work ahead will be to organize that library, to assess the collective scope of the noxious weed problem, both ecologically and economically.

To that end, the Clinton Adminstration is taking steps that will: bring together our human, technical and informational skills; establish measureable outcomes and goals; identify personnel and other resources, and report on successes with annual updates. We can use these in a way that will help detect, monitor, prevent introduction, educate the public, and pursue international cooperation on invasive alien species.

Invasive alien species will never have the power to capture the imagination, the headlines, or the nightly news in the same way *El Nino* has. But we can do something about it. For I have seen the spread from the Great Lakes to Glacier and Everglades National Park. I recognize the dangers, and scope, and impact of the spread of weeds. And my resolve and determination only hardens. We can beat this silent enemy. We can beat a threat that erodes our soil, spreads wildfire, and damages our critical water supply and property values. We can tackle a force that is toxic and painful to humans, livestock, and wildlife habitat.

But we cannot ignore it any longer. We must act now, and act as one. We owe it to ourselves and to the next generations that will seek to live from a healthy, stable landscape. Too much is at stake. I look forward to working with you.

BLM Weed Page

National Weed Symposium

April 8-10, 1998

ABSTRACTS

WILDLAND WEEDS: SCOPE, IMPACTS, STRATEGIES

Jerry Asher, Bureau of Land Management, Portland, OR

The rapid spread of weeds is causing the greatest, most rapidly accelerating degradation to the long-term health of the land today. These prolific invasive plants, also known as non-native, alien, exotic or noxious weeds, already severely reduce the health and productivity of rangelands, forestlands, riparian areas and wetlands, parks, and other natural ecosystems on many millions of acres of wildland across the American landscape. These plants generally arrive from other countries without the natural insects and pathogens that kept them in balance in their country of origin. Consequently, many of the weeds are very aggressive, and can out-compete native plants. As a result, forest regeneration and production are diminished, rangelands and family ranches are rendered nearly useless for grazing, erosion increases, streams, riparian areas and lakes are degraded, nesting for waterfowl and many other wildlife habitats are destroyed, rare plants are threatened, and recreational (fishing, hiking, camping, and boating) opportunities are reduced. Also, weeds contribute to desertification.

A 1,300 acre ranch in Oregon was recently abandoned due to infestations of leafy spurge and sold at auction for less than 15% of market value. Similarly, the value of a weed infested ranch in North Dakota was reduced by 60%. The economic impacts of leafy spurge on grazing and wildland in Montana, North and South Dakota, and Wyoming are approximately $129 million annually and represent the potential loss of 1,433 jobs. If knapweed infested all 34 million acres in Montana that are susceptible, the economic loss would be $155 million.

Even though there are dozens of commendable weed management programs and projects underway, the following examples of estimated increased weed populations illustrate the scope of the land degradation underway. In Montana spotted knapweed increased from a few plants in 1920 to 5 million acres today; in Idaho rush skeletonweed from a few plants in 1954 to 4 million acres today; in California yellow starthistle from 1 million acres in 1981 to 20 million acres today. In 1993 Jackson County in southern Oregon and Umatilla County in northeast Oregon both reported recent explosions of yellow starthistle with over 100,000 infested acres in Jackson and 200,000 in Umatilla counties. Now, a little over 4 years later they both report that the estimated populations have doubled.

We must be alert to the danger that lies ahead. These weeds increase on average about 14% per year so the rate of spread increases exponentially every year. The scientific work in the Interior Columbia Basin Ecosystem Management Project Draft EIS states, "Noxious Weeds are spreading rapidly, and in some cases exponentially ... in every cluster. Furthermore, between 33 and 66% of the BLM-Forest Service lands are susceptible to knapweeds and yellow starthistle."

We have just begun to see the scope of the future damage that will occur unless we act quickly and effectively. Estimates indicate that approximately 70 million acres of private, state and federal land are infested with noxious weeds in just eleven western states. Those 70 million acres are producing enormous amounts of seed, every year, that are being carried to other public lands by wind, water, wildlife, livestock, people and equipment. Therefore, just as predictably as lightning striking the ground thousands of times each year in every state, most of the public land is under attack from weed seed, especially land that is not yet significantly infested.

If viewed "everywhere - all at once" this problem can seem insurmountable. However, taken a watershed at a time, at the local, regional, and national level, keeping the spread of invasive plants to an acceptable level can be a reasonable endeavor. Economical, effective and successful integrated weed management strategies, including prevention, control, and restoration of infested and susceptible land, will succeed if there is cross-jurisdictional cooperation with all affected landowners, agencies, industry and user groups. That cooperation would include many partnerships with scientists and their organizations to help increase the use of scientific information and methods by local public land managers. Similarly, State Departments of Agriculture can play a major role in facilitating and encouraging formation and full implementation of cooperative weed management areas.

Outstanding opportunities also exist to protect uninfested lands. For example, of the approximately 350 million acres of Bureau of Land Management, Park Service, Forest Service and Fish and Wildlife Service lands in the west, about 90% of those lands are not significantly infested - yet. We must be wise enough and committed enough to not let the history of weed spread repeat itself over and over again across these lands we value so highly.

The Spread of Invasive Weeds in Western Wildlands:
A STATE OF BIOLOGICAL EMERGENCY

Science in Wildland Weed Management Symposium

Denver, Colorado, April, 8-10, 1998

Jerry Asher - Bureau of Land Management - Portland, Oregon
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The purpose of this paper is to explain how hundreds of public land watersheds in the west are rapidly undergoing what is perhaps the greatest permanent land degradation to ever occur in recorded history. This paper only very brief touches on Integrated Weed Management, which can be so successful in controlling weeds and preventing the spread to uninfested lands, because other speakers will address these solutions in the remainder of the symposium.

I would like to make some preliminary clarifications before I get into the details of why I call the spread of weeds on western lands a biological emergency. First, fine weed control work is underway by private, county, state and federal people and these people deserve a great deal of credit. Second, the term "permanently degraded" means with today's economics and technology and in the time frame of our children and their grandchildren. The terms permanently degraded and biological emergency are used only after considerable forethought and collaboration with many leading weed scientists, agency weed experts, and land managers. The term "permanent" is used because, even though there are dozens of commendable restoration projects underway, the amount of wildland being restored is infinitesimal compared to the amount of land that needs to be reseeded. Examples of severe and permanent land degradation are discussed because we need to learn from our experiences. There is absolutely no criticism intended. Finally, the terms exotic, alien, noxious, invasive, and non-native plants will simply be referred to as weeds.

Our basic land management goal is to maintain or improve the health of the land. This goal really means striving to have a wide variety of healthy grasses, forbs, shrubs and sometimes trees. Unfortunately, when we look at the vast public lands in the west, the greatest negative impact to healthy communities and to the restoration of less than healthy communities is the rapid expansion of invasive weeds. The best way to rate the health of a plant community is by the percent of exotic species present (Fegler, 1998).

These weed invasions all began a few centuries ago but primarily in the mid-1800's when weeds began arriving from other countries (new invaders continue to arrive here) without the natural enemies, such as insects and pathogens, that kept them in check in their country of origin. Consequently, these new plants are typically very aggressive and have the ability to dominate many wildland sites. For example, in its native habitat, purple loosestrife only comprises one to four percent of the native vegetation, but in North America densities of up to 80,000 stalks per

acre have been recorded (Strefer, 1996). Thus, purple loosestrife out competes and forces out native plant species and reduces biodiversity (Nyvall, 1995).

Lets discuss four examples of what I consider permanent land degradation. These four represent hundreds of other extensive and permanent wildland degradation situations. The purpose of discussing these examples is to show that many more western federal wildlands will move into this category of permanent degradation - if we allow that to happen.

In 1993, Jackson county in southern Oregon, and Umatilla county in north east Oregon both reported explosions of yellow starthistle with over 100,000 acres in Jackson county and 200,000 acres in Umatilla county. Now, a little over four years later both counties report that the populations have doubled! Similarly, in the BLM Cottonwood Resource Area in western Idaho, it is estimated that thirty percent of the BLM land is already infested with yellow starthistle (Wilson, 1994).

In 1970, there was about thirty-two acres of leafy spurge in the Theodore Roosevelt National Park in North Dakota. The use of herbicides was not allowed and now leafy spurge dominates over 4,000 acres of the park (Andrascik, 1997). There are over one million acres of leafy spurge in North Dakota, 600,000 acres in Montana and extensive infestations continuing to spread in Wyoming, Idaho and Oregon.

There were only minor populations of spotted knapweed in Montana in 1920. Today, there are about five million acres with another 29 million acres of highly susceptible land in that state alone (Duncan, 1997). Spotted knapweed is also expanding rapidly in Idaho, Oregon and California.

From just a few plants in western Idaho in 1954, rush skeletonweed now infests over four million acres as it continues to "leapfrog" to the east, now out beyond Shoshone, Idaho, and to the west into the Hells Canyon National Recreation in Oregon and Idaho. Severe infestations are also spreading in California, Washington and other parts of Oregon.

These examples may seem like a lesson in history. However, we have just begun to see the scope of the massive degradation that will occur in the future - if we allow that to happen. Like human populations, weeds typically increase exponentially beginning slowly, then doubling and redoubling (Kummerow, 1992).

To gain a better understanding of the term degraded, let us examine the impacts from invasive weeds to native plant communities, watershed health, wildlife, and to people. First the impacts to native plant communities which I will describe as ability to manage for desirable vegetation, permanent change in plant communities and some plant community dynamics.

Land management agency vegetative goals for properly functioning watersheds, wildlife habitat, recreation values, livestock grazing, and rare plant protection call for a wide variety of healthy native plants. Native plants form the basic biological matrix of all communities, and the growth

forms of plants are an important component of community structure (Krebs, 1994). Weeds often completely alter structure when near monocultures of one invasive plant are formed. Plant communities, such as those dominated by leafy spurge or Russian knapweed, do not have the matrix of vertical and horizontal structure or the variety of species commonly found in healthy plant communities. Weeds displace native plants, blocking the land manager's ability to meet land health goals. Aggressive foreign plants spread quickly into natural areas, monopolize resources, and push out native flora and fauna - including endangered species (Cheater, 1992).

Speculation by local land managers that dyers woad could eventually exist on most of the Cache National Forest in Utah, including the Mt. Naomi Wilderness Area, is supported by the fact that the weed was observed on fifty-five of sixty possible land cover types (Dewey, 1991). The Wilderness Act of 1964 and policy mandates that wilderness be managed to ensure that natural conditions are preserved and ecosystems and ecological processes function naturally. Invasive weeds violate that law and policy (Asher and Harmon, 1995).

Well managed land is the best defense against the spread of weeds and weeds prefer disturbed areas such as roadsides, overgrazed areas, campgrounds, trails, and wildlife bed-grounds. However, recent literature, many observations and our pictures make it clear that weeds also commonly invade relatively undisturbed communities. Several exotic noxious perennial weeds, including spotted, diffuse and Russian knapweeds, leafy spurge, and yellow starthistle are moving into excellent condition stands of native vegetation (Harris, 1991). Tyser and Key (1988) reported that spotted knapweed invaded and reproduced in rough fescue communities in Glacier National Park. Forcella and Harvey (1983) documented Eurasian weeds dominating relatively undisturbed grasslands in Montana. Several exotic weeds will invade undisturbed climax communities and can become significant components of a community (Bedunah, 1992).

The simplest effect of some invasions is the displacement of native plant species, by simple crowding, by competition for resources, or by other mechanisms. Many invasive plants form broad-leaved rosettes or in some other way shade out neighbors (Huenneke, 1996).

The impact of purple loosestrife on native vegetation has been disastrous, with more than 50 percent of the biomass of some wetland communities displaced. Monospecific blocks of this weed have maintained themselves for at least twenty years (Thompson, 1987).

When wildland weed infestations become severe and widespread, especially in rugged and rocky terrain, restoration often becomes either impractical or impossible with todays technology and economics. We usually recognize an invasion only after it has entered an explosive phase. Unfortunately, by this stage, it is difficult or impossibly expensive to control the increase of the invader. (Huenneke, 1996). When a weed infestation, like other disturbances, goes beyond a certain threshold, it becomes impossible to restore a site to the before infestation condition because of changes in structure and function in the plant community. An example is the Nature Conservancy's Altamount Prairie in South Dakota which is so badly infested with leafy spurge that it is no longer regarded as being worth managing as native prairie and cannot be sold as

cropland (Randall, 1996).

Rare plant habitat can deteriorate. Released from their natural enemies in Eurasia, weeds can be more competitive for moisture, sunlight and space especially at the germination phase.

Native plants with cultural significance, such as camas and bitterroot, are declining in number across the western landscape. This decrease is of great concern to many tribes, as traditional gathering areas have experienced a decline in productivity due to anthropogenic influences of the past century and the proliferation of invasive plant species - especially spotted knapweed and sulfur cinquefoil (Bonnicksen, 1998).

Some plants produce chemicals that reduce the germination of native plants. This affect on other plants is called allelopathy and studies indicate that Russian knapweed is allelopathic (Roche, 1989). Also, the leaf litter of salt cedar increases soil salinity so that large areas are unfit for native vegetation and the wildlife that depend on that vegetation.

A typical sequence of events is as follows: Native plant communities become infested with cheatgrass (an invasive annual grass with some forage value), which is then commonly invaded by medusahead (another invasive grass with almost no forage value), which is then frequently invaded by yellow starthistle or knapweed, which is then invaded by sulfur cinquefoil. With each step of the "downward spiral", one annual weed is replaced by another deeper rooted annual plant which is replaced by more tenacious extensively rooted perennial weeds which results in reduced site productivity and restoration becomes more difficult if not impractical.

Knapweeds, for example, are the best regional symptom of desertification, the loss of the productive potential of the land (Roche, 1988). One of the five indicators for evaluating the susceptibility for desertification is exotics as a percent of total cover (Mouat, et. al., 1993). The severe level of deterioration in four desertification classes is described in part as follows: "Undesirable forbs and shrubs have replaced desirable grasses or have spread to such an extent that they dominate the flora" (Dregne, 1977). Also the roots of some noxious weeds, yellow starthistle, leafy spurge, and rush skeletonweed for example, grow deeper into the soil profile than many native plants (Larson, 1997). This ability to tap water and nutrients otherwise unavailable to some native plants allows the exotics to out compete natives. This creates less bio-diversity and production resulting in desertification.

These last two examples, the downward spiral in plant composition and desertification overlap somewhat with what I will discuss next, impacts to watershed health. Besides the changes in plant communities, there are other impacts including reduced water flows, and increased run-off and erosion.

Salt cedar, a deep rooted shrub or small tree, uses an excessive amount. A mature salt cedar consumes as much as 800 liters of water per day -- 10 to 20 times the amount used by native species it tends to replace (Cooperrider, 1995). Salt cedar commonly draws water levels down so

completely that small springs and streams cease to flow. This has a dramatic effect on native vegetation, livestock and wildlife water and perhaps rare plants. As salt cedar displaces native vegetation, the value of the original habitat for animals is markedly diminished. Fibrous rooted native plants hold soil in place thus reducing erosion, and they promote infiltration and safe release of water and provide resilience against fire and drought. Many invasive weeds, in contrast, have primarily a tap root that does not have those beneficial characteristics. Runoff and sediment yield were fifty-six percent and 192 percent higher, respectively, for spotted knapweed than for bunch grass vegetation types (Lacey, 1989). This increased runoff, early in the season results in higher mountain stream temperatures in the summer, and the increased sedimentation degrades water quality and fish habitat.

Americans place a great deal of importance on the ability of public lands to provide quality wildlife habitat. Unfortunately, the proliferation of weeds is causing an ever increasing degradation of this habitat. Four vegetative characteristics commonly used to evaluate wildlife habitat quality include: 1.) surface plant diversity, 2.) structural plant diversity, 3.) amount of "edge", and 4.) the degree of interspersion. As weed infestations become severe, diversity declines and wildlife habitat quality degenerates (Olson, 1995).

Numerous studies demonstrate reduced numbers and/or diversity in birds, reptiles, small mammals, and insects in stands of non-native plant species. (Huenneke, 1996) For example, kangaroo rat and ground squirrel populations were severely reduced or totally eliminated on sites infested with Russian knapweed in a study in Wyoming (Johnson, 1994). Studies in Montana show that spotted knapweed invasions reduced available winter forage for elk between fifty and ninety percent (Duncan, 1997).

Wildlife habitat in riparian areas is especially vulnerable to devastation by weeds because of the extra moisture and transport into riparian areas by people, animals, and water. For example perennial pepperweed, leafy spurge, Russian knapweed and salt cedar easily form monocultures along riparian areas and adjacent uplands. Purple loosestrife forms solid stands, crowing out food plants needed by ducks and geese, and reducing suitable nesting sties. Muskrats and long-billed marsh wrens leave infested areas (Thompson, 1987).

Tamarisk (also known as salt cedar) has been able to out compete willow and other riparian plants in many locations, greatly diminishing the quantity and quality of riparian habitat for migrant songbirds and vegetation dependent birds, like the endangered Yuma clapper rail at the Salton Sea and elsewhere (Dudley, 1995). Similarly, tamarisk dominated riparian areas have depauperate faunas, even in the native range of tamarisk (Lovich, 1996). And, a study by DeLoach (1991) in the Lower Colorado Valley showed that for the entire year, salt cedar had only fifty-nine percent of the mean density of birds as the cottonwood-willow, screwbean and western honey mesquite communities. During the winter, saltcedar had only thirty-nine percent of the density of birds as other vegetative communities.

One study showed that when chukar partridge were given free access to all the medusahead

caryopses (seed) they would eat, along with other dietary requirements, they suffered dramatic losses in body weight (Savage, 1969).

Finally, weeds impact people and the way we use wildlands. Weeds affect us financially along with the opportunities for public land recreation.

Annual economic impacts of leafy spurge infestations on grazing and wildlands in Montana, North Dakota, South Dakota, and Wyoming are approximately $129,000,000 (Leitch, 1994). The reduction in wildlife-associated recreation expenditures due to current leafy spurge infestations on wildlands in North Dakota is estimated to be $2,900,000 (Wallace 1992).

In Montana knapweed infestations result in an estimated direct annual impact of $14,000,000 with total secondary impacts of about $42,000,000 per year which could support over 500 jobs in the states economy (Hirsch and Leitch, 1997). And, an economic study in Grant county, Oregon, showed the annual economic impact, just from losses in livestock grazing, was $247,000. It was estimated that those losses would climb to over $3,000,000 without increased weed management (Test, 1993).

In 1988, a 1,300 acre ranch in Klammath County, Oregon was abandoned due to leafy spurge. The ranch was then purchased at an auction for about ten percent of what it would have sold for otherwise (Humphrey, 1988). And, in 1991 a 3,200 acre ranch in Ward County, North Dakota, sold at sixty percent below market value due to leafy spurge (Weiser, 1995).

Numerous studies and repeated landowner experiences show that weeds commonly reduce livestock carrying capacity from thirty-five percent to ninety percent (Hilken, 1980; Bucher, 1993; Harris, 1988).

Without repeated investments of $100 per acre, Scotch broom partially blocks reforestation efforts and reduces growth rates of surviving trees on some timber harvest units in western Oregon (Fairchild, 1997). Similarly, rush skeletonweed is retarding forest regeneration, especially after fires, on the Boise National Forest (Ririe and Stearns, 1997).

Weeds commonly invade the most productive sites such as riparian areas, benches along streams and rivers and other sites with deep, fertile soils.

Leafy spurge causes severe eye irritation and possibly blindness in humans and it is poisonous to cattle. Infections in the eyes, mouth, and throat commonly occur in cattle and sheep feeding where medusahead is present (Bovey, 1961; Hilken, 1980). Thistles cause pain to humans trying to walk through them and yellow starthistle is poisonous to horses (Callihan, 1989).

Weeds cause abandonment of wildland recreation sites and trails. Hunters and bird dogs are reluctant to use land infested with thistles and weeds diminish the enjoyment of recreationists along trails and near campgrounds. For example, float boaters encountering the spines of thistles

and the stickery knapweeds, frequently have a difficult time finding a suitable campsite to place their tents and sleeping bags. Similarly, fishing along stream banks is often impossible because of the pain inflicted by thistles.

California is spending approximately $1,500,000 a year to control hydrilla and Wyoming spends similar amounts to reduce the spread of leafy spurge. After infestations have been allowed to become severe on wildlands, the cost of weed control commonly exceeds the market value of the land. Nevertheless, it is usually critical to control the weeds on severely infested lands to reduce the weed seed that will eventually infest other lands.

In summary, in many ways weeds are simply taking away our ability to manage for healthy and productive plant communities.

Again, far too many public land watersheds are rapidly undergoing what is perhaps the greatest permanent land degradation to ever occur in recorded history. That is because so many lands are in the process of becoming infested. This weed spread continues and science tells us that on average weeds spread about fourteen percent per year which is an exponential doubling every five years (USDI, 1985). In relation to the ecological equilibrium of native plant communities, the introduction of exotic plants can throw this balance off, possibly forever (Bedunah, 1992).
In the absence of predators, immune systems or other biological control mechanisms adapted to counteract these species, populations of some exotics have exploded (Monnig, 1992).

Invasive weeds are a major issue in the Interior Columbia Basin Ecosystem Management Project Draft Environmental Impact Statements. Many scientists worked on those documents that cover portions of seven states. Quoting from one EIS: "Weeds are spreading rapidly, and in some cases exponentially, in every cluster and sixty-six percent of the BLM/FS lands are susceptible to knapweeds and yellow starthistle" (USDA/USDI, 1997).

Now let us review more examples of explosive wildland weed spread.

In one research area in Colorado, dalmation toadflax recently increased 1,200 percent over a six year period (Beck, 1998). Similarly, field inventory data in the South Fork drainage in northwest Wyoming showed that dalmation toadflax increased from four acres in 1985 to 2,000 acres in 1997 (Christy, 1998). This data supports the field observations by BLM employees in Prineville, Oregon, who for many years have taken a management trip during the first week in June every year through wilderness study areas along the Lower John Day River. In 1996, they returned from the trip reporting their astonishment that the dalmation toadflax populations had doubled in size from 1995. Following their 1997 trip, they reported that the toadflax had doubled in size again!

Six invasive weeds have invaded extensive areas of undisturbed Sonoran desert vegetation. The invasions appear to be irreversible and other exotic species show signs of becoming increasingly invasive (Burgess, 1991). For, example bufflegrass is a non-native grass that is aggressively

invading the Sonoran desert. Where bufflegrass is dense enough, it can carry fire into Sonoran desert vegetation that has no natural adaptation to fire. Within the next several decades, buffelgrass might displace many common plants native to this desert (Rutman, 1997).

Near the Lower Salmon River on BLM land in Idaho, a 1983 "range trend record" picture and accompanying vegetative data show a complete absence of yellow starthistle. A picture from that same transect in 1993 shows almost total domination by yellow starthistle.

Field inventory data in the Renner watershed on BLM land near Worland, Wyoming, shows that hoary cress increased from fourteen acres in 1990 to 2,000 acres in 1995 (Christy, 1998). Similarly, in the Keating Valley of eastern Oregon, hoary cress was confined to the farmland fifteen years ago. Today hoary cress extensively dominates BLM lands (that are critical deer winter range) surrounding that valley.

Sixteen years ago yellow starthistle infested about 1,000,000 acres of land in California. Today, population estimates range up to 20,000,000 acres (O'Connel, 1998).

If all this isn't bad enough, lets discuss examples of weed spread following fire. Please keep in mind: we are *not* saying fire is bad. Fire is often very beneficial to plant communities, but fire can also result in massive increases in bad actor weeds - if we allow that to happen. And, we need to recognize that, as cheatgrass invades an area, the frequency of fire is likely to increase. For example, cheatgrass invasion has increased the frequency of fires from once every sixty to 110 years to once every three to five years on millions of acres of rangeland in the Great Basin (Whisenant, 1990). There are great opportunities to control bad actor weeds with prompt post fire weed detection followed by timely control before the weeds set seed. Here are some examples of post-fire-weed increase.

Near Tintic Junction and Perry, Utah, pictures of fire line contrasts between burned and unburned areas make it obvious that when squarrose knapweed or dyer's woad, is a minor component of a plant community those weed populations commonly explode after fire. When Pat Fosse, with BLM in the Fillmore (Utah) Field Office, studied nine major weed infestations in her area of responsibility, she found that all of those weed infestations are in areas that have burned recently.

In the Sellway Bitteroot Wilderness in Idaho and Montana, spotted knapweed frequently becomes the dominate plant after fires. In 1993, the Forest Service District Ranger explained how he wished he could employ crews to promptly return to burned areas to search out and destroy new spotted knapweed infestations for a few years to give the native vegetation a chance to become well established. The cost of that weed control would be a pittance in comparison to the amount of money wisely spent controlling the fires (Dailey, 1993).

Dalmation toadflax exploded recently after wildfires in parts of Yellowstone National Park. Similarly, a few musk thistle plants were noticed in 1995 in a woodcutting area on BLM land near Montrose, Colorado. Following a wildfire in 1996, musk thistle populations now form near mono-

cultures over large areas.

Where there were only a few plants of hoary cress in 1996 before the Broken Back fire on BLM land near Worland, Wyoming, there is now a major population of this noxious weed (Christy, 1998).

Accelerated by wildfire, yellow starthistle now infests about twenty-five percent of the Forest Service Ishi wilderness in northern California.

In the BLM Sand Butte and adjoining Wilderness Study Areas in Idaho, considerable weed surveillance had been underway for many years. Until a huge wildfire burned over the area in 1992, rush skeletonweed was not known to exist there. In 1995, a few rush skeletonweed plants were found and controlled. In 1996 the entire area burned again. A preliminary detection survey in 1997 outlined a 60,000 acre area that now has serious rush skeletonwed infestations scattered within.

One indication of how these bad actor weeds are so competitive is shown in a series of pictures we have of squarrose knapweed, diffuse knapweed and rush skeletonweed quickly sprouting and setting seed within five to eight weeks after fires. Thus, these weeds promptly produced their second crop of seeds while all other plants were awaiting another season to arrive. .

The Departments of Agriculture in eleven western states estimate that there are about 57,000,000 acres of invasive weeds on private, state and federal wildlands. Essentially, this means there are 57,000,000 acres of weed seed being produced every year, much of which is being carried to other wildlands by wind, water, wildlife, livestock, people and equipment. Consequently, just as predictably as lightning strikes ever year, anywhere, all the public lands are under attack from these weed seeds.

The magnitude of this problem can leave us feeling overwhelmed. But, if we had just discussed wildlife management, or range management, everywhere - all at once - like we just discussed weeds, we would also feel overwhelmed. However, in local watersheds (someone is responsible for every piece of land), cooperative weed management can be a reasonable and successful endeavor - especially if we remember that about ninety percent of the 350,000,000 acres of western public lands are not significantly infested - yet. Cooperation is the key, and that is why cooperative weed management areas are so urgently needed. A county, state and federal effort produced the "Guidelines for Coordinated Management of Noxious Weeds in the Greater Yellowstone Area" (USDA/USDI, 1992) which can help people initiate and implement cooperative weed management areas.

How urgent is it to control weeds, especially the thousands of new or small infestations currently growing out of control in relatively uninfested areas? Let us consider the priority in relation to fire. Nature often helps put out fires, nature does not help put out weeds. Fires are often very beneficial, weeds are not beneficial. If and when there are negative impacts from fire, they are

usually short-term, whereas impacts from weeds are long term and often permanent. Therefore, the thousands of small/new infestations that are currently growing out of control on relatively uninfested land, truly constitute a state of biological emergency!

In conclusion, we must cooperatively keep relatively uninfested public land from becoming seriously infested. Future generations of Americans deserve to inherit healthy productive landscapes, not vast landscapes infested with spiney, poisonous weeds that are unfit for people or wildlife. We must be wise enough and committed enough - right now - to fully engage science and fully implement enough cooperative weed management areas so that the history of weed spread does not repeat itself over and over again across these public lands we value so highly.

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BLM Weed Page

National Weed Symposium

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ABSTRACTS

SQUARROSE KNAPWEED DEMONSTRATION WEED MANAGEMENT AREA

Pat Fosse, Bureau of Land Management, Fillmore, Utah

Squarrose knapweed (Centaurea virgata var. squarrosa) is an invasive perennial noxious weed that was introduced into the U.S. from the eastern Mediterranean region. The original introduction in Utah is known to have been in Juab County near Tintic Junction and there are undocumented reports from as early as 1928. By May of 1954 it was scattered over a few hundred acres within one township. Concerns expressed by local land managers resulted in two meetings in 1954 to discuss action recommendations. It was decided that the weed was primarily a threat to cropland and would not invade rangeland, and therefore was not cause for alarm. The recommendation was to do more research rather than initiate an eradication program. A committee was formed to coordinate the research and control effort. A report of the research was published by Utah State University in 1960. No documentation of any control work was found for the period from 1960 to 1981. Interest was revived for periods of a few years beginning with the formation of various committees in 1981 and 1986. Control efforts each time were fragmented between county, private, and federal entities due to limited budgets, communication, and cooperation. By this time squarrose knapweed had spread over an estimated 100,000 acres of rangeland in at least five counties.

During 1992, the Tri-County Squarrose Knapweed Committee was formed. In order to raise awareness of the problem, a knapweed pamphlet was developed and an annual tour was started in 1993. During 1994 several proposals for management were created by the then, loosely knit committee, and forwarded to different agencies and individuals. As a result of these proposals, the Fillmore Office, Bureau of Land Management (BLM) received some earmarked funding in 1995 to begin working on this problem. This money was used to complete a GIS inventory of the squarrose knapweed infestation as well as begin control efforts in high priority areas. This was done cooperatively between Juab County and the BLM.

During the fall of 1995, four areas in western states were selected as Demonstration Weed Management Areas (DWMAs) by the Bureau of Land Management. DWMAs are intended to highlight what can be accomplished through cooperative efforts and partnerships and will be used to document successes and failures in order to provide guidance in the development of other weed management areas. The Squarrose Knapweed Management Area was selected as one of the DWMAs.

The Squarrose Knapweed DWMA includes portions of four counties including Juab, Utah, Tooele and Millard. The 1995 general inventory of the DWMA indicated that there were approximately 150,000 acres of squarrose knapweed within the DWMA. Other noxious weeds including dyer's woad, Scotch

thistle, purple loosestrife, spotted knapweed, Russian knapweed and low whitetop also occur within the DWMA. These noxious weeds occur mostly as small isolated patches or individual plants. A Management Plan was developed by a planning and implementation team composed of twelve individuals from different agencies and groups, including representatives from each of the four counties. Common goals and objectives were developed by the planning team. Then an integrated weed management plan, with four major components was developed to achieve our common goals. The four components of the plan are prevention, detection, suppression (control), and revegetation/rehabilitation. When the plan was in draft form, it was widely distributed for review and comments. Many good comments were received and were incorporated into the plan. There are currently 27 partners working together to manage the Squarrose Knapweed DWMA. The partners, led by the planning and implementation team, have worked together to begin implementing the plan over the past two years.

Progress towards meeting goals and objectives has been greatly accelerated by working together with a common goal. Some of the accomplishments include: A widespread and effective education and awareness campaign is ongoing. A general GIS inventory of the entire WMA was completed in 1995 and is continually being updated. Over 4,000 miles of roadway were treated during 1997. Over 8,800 acres of burned area was treated aerially for squarrose knapweed during the fall and spring of 1996/97 prior to reseeding efforts. Nearly 1,600 acres within high priority areas were treated aerially during May of 1997 and an additional 1,400 acres was treated from ground rigs. All identified high priority areas and spot infestations, as well as "mop up areas" in the burned areas, were treated during 1997. Six biological control agents have been released within the DWMA. Two of these biological control agents, seedhead flies, now occur within all areas of the squarrose knapweed infestation and are affecting seed production by 50% to 80% in some areas. Three separate research projects are in different phases of development and implementation and 31 monitoring transects have been established to measure progress. The research results and monitoring data will be widely distributed. Research is geared towards looking for long-term solutions, not just treating symptoms of the problem. The partners have established a mutual trust and good working relationship.

The ONLY way to succeed in the management of a biological problem, such as noxious weeds, that knows no boundaries, is to remove the boundaries in our minds when we are dealing with the problem and work together to set priorities, implement plans, and accomplish common goals. Using the best science is critical to success, the best biological science, as well as the best social science.

COOPERATIVE WEED MANAGEMENT AREA EXPERIENCES

Squarrose Knapweed Demonstration Weed Management Area

By: Pat Fosse, Assistant Area Manager
Bureau of Land Management, Fillmore Field Office

One of our highest priorities as land managers is to maintain or improve the health of the land and part of our mission is to preserve options for future generations. We all agree that to do this, we must use the "best science". When we hear the word science, most of us think of biological science. We have been trained in biological science, we know where to find the answers to many of our questions or to propose new research to unanswered questions. However, when managing a biological organism, such as noxious weeds, which have no boundaries, we must also use the best SOCIAL science to be successful in achieving our goals. Cooperative Weed Management Areas (CWMA) offer us the opportunity to use the best social science as well as the best biological science. This paper addresses the history, learning experiences, and successes of one CWMA in west central Utah.

Squarrose knapweed (*Centaurea virgata* Lam. var. *squarrosa* Gugl.) is an invasive perennial noxious weed that was introduced into the U.S. from the eastern Mediterranean region. It is a long-lived plant, that is extremely aggressive and competitive. The deciduous seed heads and re-curved bracts on the seed head allow for extremely efficient seed dispersal. The deep taproot of squarrose knapweed allows it to effectively compete with desirable perennial vegetation for soil resources. The original introduction in Utah is known to have been in Juab County near Tintic Junction. There are undocumented reports of sightings of squarrose knapweed from as early as 1928. By May of 1954, it was scattered over a few hundred acres within one township. Concerns expressed by local land managers resulted in two meetings in 1954 to discuss action recommendations. Through these discussions, it was decided that the weed was primarily a threat to cropland, would not invade rangeland, and therefore was not cause for alarm. The recommendation was to do more research rather than initiate an eradication program. A committee was formed to coordinate the research effort. A report of this research was published by Utah State University in 1960. No documentation of any research or control efforts is found for the period from 1960 to 1981. Interest was revived, for periods of a few years, beginning with the formation of various committees in 1981 and 1986. Control efforts each time were fragmented between county, private, and federal entities due to limited budgets, communication, and cooperation. By this time squarrose knapweed had spread over an estimated 100,000 acres of rangeland in at least five counties.

During 1992, the Tri-County Squarrose Knapweed Committee was formed. In order to raise awareness of the problem, this committee developed a knapweed pamphlet and organized an annual tour, which began in 1993. During 1994, several proposals for management were created by the then, loosely knit committee, and forwarded to different agencies and individuals. As a result of these proposals, the Fillmore Office, Bureau of Land Management (BLM) received some earmarked funding in 1995 to begin working on this problem. This money was used to complete an inventory of the squarrose knapweed infestation as well as begin control efforts in high priority areas. Global Positioning System (GPS) and Geographical Information System (GIS) were the tools used in this inventory. This was a relatively general inventory that cost less than one cent per acre for the ground work. The inventory was accomplished through cooperative efforts between Juab County, Utah Department of Agriculture and the BLM, Fillmore Field Office.

During the fall of 1995, four areas in western states were selected as Demonstration Weed Management Areas (DWMAs) by the Bureau of Land Management. DWMAs are intended to highlight what can be accomplished through cooperative efforts and partnerships and will be used to document successes and failures providing guidance in the development of other weed management areas. The Squarrose Knapweed Management Area was selected as one of the DWMAs.

The Squarrose Knapweed DWMA includes portions of four counties in Utah including Juab, Utah, Tooele and Millard. The 1995 general inventory of the DWMA indicated that there were approximately 150,000+ acres of squarrose knapweed within the DWMA. Other noxious weeds including dyer's woad, Scotch thistle, purple loosestrife, spotted knapweed, Russian knapweed and low whitetop also occur within the DWMA. These noxious weeds occur mostly as small isolated patches or individual plants. The first step in management of the DWMA was to develop a Management Plan. This was accomplished by a planning and implementation team composed of twelve individuals from different agencies and groups, including representatives from each of the four counties. Common goals and objectives were developed, followed by an integrated weed management plan with four major components to achieve these goals. The four components of the plan are prevention, detection, suppression (control), and restoration/rehabilitation. While the plan was in draft form, it was widely distributed for review and comments. Many good comments were received and incorporated into the plan.

There are currently 27 partners working together to manage the Squarrose Knapweed DWMA. The partners, led by the planning and implementation team, have worked together to implement the plan over the past three years. Each year an Annual Operating Plan is developed by the Planning Team. Through this, priorities are established, assignments given, and goals and objectives are re-visited to determine if anything has been learned warranting change of the initial plan and determining if action items and objectives are still on track to meet the goals.

The long-term goals are to: (1) educate the general public and internal personnel about the impacts caused by non-native invasive plants, (2) prevent the spread of squarrose knapweed and other noxious and invading weeds, and (3) through integrated weed management practices, reduce the infestation of squarrose knapweed, both population and acreage, to a level where biological control, along with proper management practices, will keep the weed in check within the ecosystem.

The partnership intends to demonstrate which methods and actions most effectively and efficiently helped attain the goals and objectives. It will also demonstrate how cooperation and partnerships benefit all partners and agencies involved, and how the synergy or momentum created through successful partnerships or teams allow more innovation, creativity, effectiveness, efficiency and flexibility in a project.

Many valuable lessons have been learned over the past three years, along with the accomplishment of an enormous amount of work on the ground. Some of the things which have been learned are written in a paper entitled "Tips on Organizing a Weed Management Area Partnership". This is included as an attachment to this paper. It is relatively simplistic, but offers some basic operational type suggestions on how to get organized and started.

Progress towards meeting goals and objectives has been greatly accelerated by working together with common goals. Some of the accomplishments are listed below.

A widespread and effective education and awareness campaign is ongoing. A general GIS inventory of the entire DWMA was completed in 1995 and is continually updated as the counties complete comprehensive noxious weed inventories independently or in conjunction with other agencies. The inventory information is available to all interested partners via the internet.

Over 4,000 miles of roadway were treated with herbicides within the DWMA during 1997. Over 8,800 acres of fire rehabilitation area from 1996 wildfires were treated aerially for squarrose knapweed during the fall and spring of 1996/97. Nearly 1,600 acres within high priority areas were treated aerially during May of 1997 with an additional 1,400 acres treated from ground rigs. All identified high priority areas and spot infestations, as well as "mop up areas" in the fire rehabilitation areas, were treated during 1997. High priority areas, as identified by the Planning Team, include all of the new and/or small infestations along the perimeter of the infestation as well as those areas within the "main hub" of the infestation that are contributing to the spread of squarrose knapweed. Examples of high priority areas within the "main hub" of the infestation are gravel pits, sheep trails, ATV trails, road right-of-ways, heavily used recreation areas, railroad right-of-ways, livestock and wildlife watering areas, and burned areas.

Seven biological control agents have been released within the DWMA. These agents include the banded gall fly, *Urophora affinis,* UV knapweed seed head fly, *Urophora quadrifasciata,* grey-winged root moth, *Pterolonche inspersa,* bronze knapweed root-borer, *Sphenoptera jugoslavica,* lesser knapweed flower weevil, *Larinus minutus,* sulphur knapweed moth, *Agapeta zoegana,* and broad-nosed seed head weevil, *Bangasternus fausti.* Two of these biological control agents, both seedhead flies, now occur within all areas of the squarrose knapweed infestation and are affecting seed production by 50% to 80% in some areas.

Three separate research projects are in different phases of development and implementation, they are all designed to improve our efficiency and effectiveness in managing squarrose knapweed in a sustainable way and maintaining or improving the health of the land. Many partners are involved in the research and monitoring within the DWMA. These partners include USDI Bureau of Land Management, Utah State University Extension, Dow AgroSciences, Utah DWR Great Basin Research Station, USDA Rocky Mountain Research Station, USDA APHIS, USDA Agricultural Research Service, Utah State Department of Agriculture, Juab County, Millard County, Tooele County and Utah County.

Thirty monitoring transects have been established by BLM personnel with guidance from academia regarding an appropriate methodology to answer the questions. With the data gathered from this monitoring and current research projects, the most effective treatment and restoration methods for squarrose knapweed infestations will be determined; answering questions like, Which desirable perennial plants will be most competitive? How and when do we plant? Do we need to use herbicides prior to seeding and if so, which herbicides are most effective?

Criteria used to determine monitoring methodologies include: 1) gathering data is not time consuming or complicated, 2) data is statistically reliable and 3) data will answer questions and be operationally useful. Local field personnel can gather valuable data which helps make more efficient and effective decisions using the listed criteria.

The partners working on biological control measure progress with four different monitoring schemes including, 1) percent seed reduction, comparing average number of viable seeds produces in infested seed

heads with those in non-infested seed heads, 2) insect population density, establishing a population trend 3)insect recovery spot check to determine reproduction and disbursement of each biological control agent and 4) measurement of long term impacts of biological control agents on squarrose knapweed.

The research and monitoring results will be shared with all partners and/or published in Technical and Professional Society Papers.

Key to the success of the squarrose knapweed DWMA partnership has been the establishment and maintenance of mutual trust enabling a good working relationship.

Weed management CAN BE successful, therefore maintaining or improving the health of the land and preserving options for future generations. However, the ONLY way to succeed in the management of a biological problem, such as noxious weeds, which recognize no boundaries, is to remove the boundaries in our minds and work together to establish goals, set priorities, develop and implement plans, and achieve results on the ground. Using the best science is critical to success....the best biological science AND the best social science.

TIPS ON ORGANIZING A WEED MANAGEMENT AREA PARTNERSHIP

Pat Fosse, Assistant Area Manager, BLM, Fillmore Field Office
Team Leader, Squarrose Knapweed DWMA

Somebody needs to be the catalyst in starting a Weed Management Area (WMA). That "somebody" can be a rancher, a county extension specialist, a county weed supervisor, a state or federal employee, or some other interested person, it doesn't really matter who it is, as long as that person is sincere and credible.

- Plan initial meeting

Select tentative geographical area

Invite ALL potential partners/landowners to the meeting.
Be prepared with some maps, a list of the known noxious or invasive weeds in the area, and an estimation of the infestation.

Give an overview of the problem and the impacts or threats to the resources in the area. Show how similar weeds have infested large areas in adjoining areas or states.

Have an open discussion of the problem and ask the group to select a team leader and planning team members to take the lead in preparing and implementing the plan.

The Squarrose Knapweed Demonstration Weed Management Area (DWMA) started with ten planning team members. Each County Commission, as well as each agency involved, selected a person from their respective agency whom they felt could provide the team with useful input and/or had field knowledge that was necessary for planning efficiently.

Give each of the counties or agencies a week or two to select a planning team member. Emphasize the need to select people that have good social skills, a high level of commitment and energy, and a positive attitude to be on the planning team. Selection of the initial planning team members is probably one of the most important steps towards long-term success of the plan.

Don't worry too much about the partners that do not show up, especially at first. The main emphasis should be on getting the ball rolling, showing some progress in some visible and high priority areas.

Planning Team Responsibilities:

Prepare the Weed Management Plan

Decide on the geographical area of WMA.

Develop goals for the WMA. Develop objectives for prevention, detection, control, and rehabilitation.

Make sure the goals and objectives are reasonable and attainable. Also discuss communication and monitoring goals. These can be developed in subsequent meetings.

Estimate infestation levels and set management priorities. Discuss options to complete a general inventory early on in the process. In a dynamic ecosystem a general inventory is usually sufficient to begin with. More specific inventories can be completed later as needed or in high priority areas. Global Positioning System (GPS) and Geographical Information System (GIS) have been excellent tools for us in detection because once the GPS data is gathered, by any of the partners, it can easily be shared with everyone via the internet.

Set priorities, based on goals and objectives. Setting priorities for treatment, especially in areas with that currently have large infestations of noxious weeds, can help partners focus on progress and not get overwhelmed and give up. Within the Squarrose Knapweed DWMA, high priority areas for herbicide treatment include the small infestations or individual plants along the perimeter of the infestation, as well as any areas within the "main hub" of the infestation that were likely to contribute to the spread of the weed. High priority areas within the "main hub" of the infestation includes areas such as road right of ways, livestock trails and watering areas, recreation areas, railroad right of ways, utility corridors, and gravel pits.

When the plan is in draft, send it out and solicit input from everyone you can think of. We sent out approximately 200 copies of the Squarrose Knapweed Management Plan and received many excellent comments and ideas. As a planning team, discuss and include any applicable input.

Implement the Weed Management Plan

Once the plan is finalized and the Memorandum of Understanding has been signed, the planning team should implement it through their respective agencies and the other partners. We have done this through three to six planning meetings per year to develop an Annual Operating Plan, based on the goals and priorities established in the Plan. While

developing the Annual Operating Plan, it is appropriate to re-visit the goals and priorities as a first step to determine if gained information or changes on the ground warrant changing priorities or goals. Once consensus is reached on the priorities for the year, it is helpful to assign each high priority control area to a couple of team members to ensure that the work is completed. Spread the assignments between all willing partners and keep the assignments within the partner's jurisdictional areas whenever possible. Other partners or groups help on many of the assignments, but the responsible team member makes the arrangements or makes sure that it gets done. Each year we also determine how we can help each other get the job done given our varying resources. Some of us have money, but no equipment, some have time, but no money, etc. So we throw our resources into a pool and determine how to use what we have to complete our task in the most efficient and effective way. Also, at these meetings we look for "weak links in the chain" or partners that are not moving ahead and seek solutions or ways to help them get involved. Not all partners will be able to contribute equally or even proportionally, so just be willing to trust them and accept and thank them for what they can contribute .... a piece of equipment, some of their time, some money, some knowledge, some experience, etc. Readily share recognition for results with the other partners.

As a planning team, we get out on the ground and work together in a couple of high priority areas each year. When we do this, we plan a pot luck or barbecue for lunch. This helps to develop mutual trust and good working relationship, which will contribute to the long term success of the project.

A field tour should be set up early on in the process to show the problem. All affected landowners, agencies, groups, academia, and politicians should be invited. As results are obtained on the ground, additional annual tours are helpful to gain and keep support, as well as for education and awareness. During the annual tour or once a year at an appropriate time, give recognition to an outstanding contributor. Engraved plaques and recognition in the local newspaper are effective ways to pat people on the back for their contribution and may also inspire neighbors, peers, etc. to jump on the band wagon.

Move fairly quickly to get through the paperwork stage and show some results on the ground. If people do not see some progress on the ground in the first year or two, you may lose some support.

Monitoring should also start early in the process, photo points of pre-management infestations should be taken in several areas. A monitoring scheme should be planned and baseline data gathered. We must be fanatics about measuring progress, that is how we maintain support. As soon as results are noticeable, it is helpful to develop a slide show or display to use for education, awareness and support.

Even if only a few committed people show up at the first meeting or the planning team

meetings, keep moving ahead. We found that as we began to show results on the ground, the project gained momentum, more partners, more money .... the "snowball rolling down hill" effect. Don't ever give up.

Be willing to share resources whenever possible to meet objectives in highest priority areas. Be as flexible as possible. Many times we can use each other's processes to more effectively and efficiently reach objectives. For example, the county contracting process is much simpler and less time consuming than the federal contracting process, so if you have an area that needs to be treated within a short time frame, you could transfer the money to a county, they can hire the contractor and the area can be treated much sooner and usually for less money.

If you make mistakes, admit it, learn from it, share what you have learned, adjust, and move on. If you have tried to do something and failed, you are vastly better off than if you have tried to do nothing and succeeded.

In Weed Management, it is easy to get discouraged or overwhelmed, so try to dwell on the successes and progress and not lose site of the goals and priorities. If you determine that the goals you set are unrealistic or unattainable, change them. In many cases it took these weeds several decades to reach current infestation levels, so it is unreasonable to expect to control them or get them under control in a few short years. Persistence is the key. Encourage each other and pat each other on the back often. It helps.

A "lets find a way to make this work" attitude is essential.

Squarrose Knapweed DWMA Planning Team

BLM Weed Page

National Weed Symposium

April 8-10, 1998

ABSTRACTS

PULLING TOGETHER IN SCIENCE-BASED WEED MANAGEMENT

Steven A. Dewey, Ph.D., Utah State University

Embracing the "science" of weed management and basing field practices on scientifically proven facts makes land managers much more effective in coping with invasive plant species on wildlands. Weed management decisions that disregard scientific methods in favor of anecdotal information, casual observations, and offhand remedies ultimately result in confusion, waste, frustration, and failure.

The primary purpose of this symposium is to help land managers make greater use of science in their local day-to-day weed management activities. The phrase "best use of science in weed management" can have at least two meanings for public land managers. One is to find, recognize, and take advantage of all currently existing science-based information about wildland weeds and their control. The other is to generate useful new information through scientific experimentation. There is much more sound weed management information already in existence than is being used by most land managers, and there is far more new information waiting to be discovered through future research.

Current science-based weed information can be obtained from university, industry, or federal research scientists; local Extension personnel and publications; professional weed science society conferences and workshops (national, regional, and state); weed science society publications (journals, proceedings, special reports); and even weed science internet web pages. When a search of reliable sources fails to uncover enough data to address specific wildland weed problems, cooperative scientific studies between public and/or private research organizations can be an effective way to generate needed additional data. Research partners might include universities, herbicide manufacturing companies, State Departments of Agriculture, private consulting firms, or other federal agencies.

Some of the most useful new weed management information often is obtained through very simple research conducted by local land managers. Most such experimentation can be conducted as part of routine weed management activities, requiring little or no additional time or effort. The key is to include planned comparisons between two or more treatments, using any simple but valid experimental design, with some degree of replication (time and/or space). Monitoring, measuring, recording, and reporting treatment differences using accepted scientific methods and standards results in valuable data that can be used reliably by others facing similar weed problems.

Field monitoring is becoming a required part of essentially all field operations on public lands. It takes no longer to monitor and collect data from a well designed experiment than from a poorly designed one. The

only difference is in the reliability of the data. Even the most simple research design, such as applying a test herbicide as 2 or 3 separate strips rather than in a single block, can mean the difference between gathering useful or worthless data.

"Pulling together" in science-based weed management means closer cooperation between scientists and land managers in sharing needs, new ideas, and discoveries. Through such partnership efforts, weed management will become much more effective and efficient, with a corresponding increase in public confidence and support for efforts to control invasive plant species on public lands.

Pulling Together in Science-Based Weed Management

Steven A. Dewey, Ph.D., Utah State University

The alarming spread and serious negative impacts of invasive non-native plants on wildlands has been effectively illustrated by our previous speakers. There can be little doubt that a situation like this (a single dyer's woad plant at the side of a trail in the Wellsville Peak Wilderness Area of northhern Utah) will eventually lead to drasitic ecological changes (illustrated by a more advanced infestation of dyer's woad just a mile away at the edge of the same wilderness area) if not corrected in a timely manner.

Recognition of the seriousness of the invasive plant issue is resulting in strong partnerships and extraordinary cooperation between private and public land managers, environmental advocates, and other key special interest groups. A growing concern is evident at all levels within the federal land management agencies, and all are demonstrating greater commitment to "pull together" in effective partnerships to address this critical problem.

One of the most essential "partners" in this national effort is not an individual or an organization, but a principal or a tool. It is the use of science. The primary purpose of this symposium is to help land managers "pull together" further by making greater use of science in local day-to-day weed management activities. Embracing the "science" of weed management and basing field practices on scientifically tested facts will make land managers much more effective in coping with invasive plant species on wildlands. Neglecting scientific information and methods in favor of anecdotal information, casual observations, and hearsay will ultimately reap waste and disappointment.

The phrase "best use of science in weed management" can have at least two meanings for public land managers. One is to find, recognize, and take advantage of all currently existing science-based information about wildland weeds and their control. The other is to generate useful information through new scientific experimentation. There is much more sound weed management information already in existence than is being used by most land managers, and there is far more new information waiting to be discovered through additional research.

Current science-based weed information is available from a variety of sources. Professional weed science research organizations exist at the international, national, regional and state level. Valuable scientific information can be found by attending their conferences, or reading their journals and other publications. Extension publications offer another valuable source of science-based weed information, as are the many Extension weed management training seminars and workshops. Some federal agencies also offer internal weed management short-courses that are excellent sources of information. Internet sites maintained by regional and national weed science organizations are excellent sources of useful information on a variety of weed topics.

When a search of reliable sources fails to uncover enough information to address specific wildland weed problems, then additional research data must be generated. Involvement by federal land managers in this process can occur in a variety of ways. The most simple (but highly important) is to help scientists identify research needs or "information gaps", by communicating to them the specific field situations or unanswered questions that are causing frustration.

A higher level of involvement is to participate as an actual research partner. Cooperative scientific studies between public and/or private research organizations are probably the most effective way to generate needed additional data. The role of a local land manager partner could be in the form of providing researchers with a field study site, sharing equipment, donating labor, monitoring sites, or contributing financial support. Research partners might include universities, herbicide manufacturing companies, State Departments of Agriculture, private consulting firms, or other federal agencies.

Independent research conducted by local land managers provides some of the most useful new weed management information. Often, it can be obtained through very simple research, conducted as part of routine weed management activities and requiring little or no additional time or effort. The key is to include planned comparisons between two or more treatments, using a simple but valid experimental design, with some degree of replication (time and/or space). Monitoring, measuring, recording, and reporting treatment differences using accepted scientific methods and standards will provide valuable data that can be used reliably by others facing similar weed problems. Field monitoring is becoming a required part of essentially all field operations on public lands. It takes no longer to monitor and collect data from a well designed study than from one that is poorly designed. The difference is in reliability of the data.

"Pulling together" in science-based weed management means closer cooperation between scientists and land managers in sharing needs, new ideas, and discoveries. Through such partnership efforts, weed management will become much more effective and efficient, with a corresponding increase in public confidence and support for efforts to control invasive plant species on public lands.

BLM Weed Page

National Weed Symposium

April 8-10, 1998

ABSTRACTS

PREVENTION AND THE INVADERS DATABASE

Peter Rice, Biological Sciences, University of Montana, Missoula, MT 59812, biopmr@selway.umt.edu

A strategic weed management plan must start with professional awareness of new invaders. This will allow deployment of preventive tactics to exclude or quarantine, and facilitate early detection before an exotic species becomes a permanent member of the flora. Most regulatory mechanisms declare a species as noxious only after the weed is so wide spread that we have lost the opportunity for eradication or containment. We then must initiate areal mapping and large scale suppression programs; and we are forced to consider evoking alternative land use or what we are now calling "ecological management". Each weed management tactic being employed at ever increasing costs in addition to the cumulative negative environmental and economic impacts of the infestation.

Models and empirical data on the spread and management of diseases, and the distinction between public health actions which focus on preventing outbreaks and spread in contrast to the treatment of individual patients, have relevance to the management of invasive plants. For at least forty years a minority of weed scientists have proposed that weed epidemiology be a fundamental prerequisite of weed management planning. The role of government in weed management, and the infestation thresholds that trigger deployment of counter measures, differ from those of individual landowners. These landowners include government entities that manage specific tracts of public land. However, policy makers and program directors have been largely unwilling to divert limited resources from management of the most apparent crises. We might acknowledge the importance of early intervention, but have failed to shift emphasis from control to prevention.

The INVADERS Database and Software were designed as strategic analytic tools to support pro-active weed management. A plant name catalogue list 1,023 exotic plant species that have been reported in five northwest states. Sixty thousand distribution records, starting in 1875, track the historic spread of 882 exotics. The INVADERS-Windows and INVADERS-WEB (http://invader.dbs.umt.edu) interfaces allow users to easily query the database. Outputs include county resolution presence/absence maps, time sequenced spread maps, expansion rate curves, and regional lists of exotic flora. More detailed analyses of record locale statements and data on associated vegetation are used to predict which habitats are susceptible to invasion by individual exotic species. Locale statements can be ported to GIS to develop bioclimatic envelopes and predict potential maximum ranges for invasive species. These data outputs have practical applications for both Weed Management Area plans and regional scale (multi state +) strategic management programs.

The INVADERS database structures and user interfaces were designed to be expandable to include other states or a national scale invasive plant database. A National INVADERS Database on the web would have several important advantages over a Windows PC version. 1) The web site allows near universal access to the data. 2) The database can be updated on a regular basis and new output formats can be added without the complications and cost of distributing the updates on diskettes to the users. 3) We can program it so taxonomically qualified users could submit new data directly to the database and have it immediately available as part of the output lists, maps, graphs, etc. for their projects and reports. This allows us to move to a community (multi agency) invasive plant database.

Prevention and the INVADERS Database

http://invader.dbs.umt.edu

Peter Rice
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strategy: the science and art of analyzing the multitude of enemy forces and planning long term responses that efficiently utilize the nation's resources
tactics: the science and art of deploying force to obtain immediate objectives against individual elements

SUMMARY

A strategic weed management plan must start with professional awareness of new invaders. This will allow deployment of preventive tactics to exclude or quarantine, and facilitate early detection before an exotic species becomes a permanent member of the flora. Most regulatory mechanisms declare a species as noxious only after the weed is so widespread that we have lost the opportunity for eradication or containment. We then must initiate areal mapping and large scale suppression programs; and we are forced to consider evoking alternative land use or what we are now calling "ecological management". Each weed management tactic is employed at ever increasing costs in addition to the cumulative negative environmental and economic impacts of the infestation.

For at least forty years a minority of weed scientists have proposed that weed epidemiology be a fundamental prerequisite for planning weed management. Models and empirical data on the spread and management of diseases, and the distinction between public health actions which focus on preventing outbreaks and spread in contrast to the treatment of individual patients, have relevance to the management of invasive plants. The role of government in weed management must differ from that of individual landowners. Some agencies are also "landowners" that manage specific tracts of public land, but agencies have responsibility beyond the individual tracts . The infestation thresholds that trigger deployment of counter measures must be lower than the agronomic thresholds for single tracts in order to prevent spread. However, policy makers and program directors have been largely unwilling to divert limited resources from management of the most apparent crises. We might acknowledge the importance of early intervention, but have failed to shift emphasis from control to prevention and containment.

The INVADERS Database and Software were designed as strategic analytic tools to support pro-active weed management. A plant name catalogue list one thousand exotic plant species that have been reported in five northwest states. Sixty thousand distribution records, starting in 1875, track the historic spread of 882 exotics. INVADERS for the WEB (**http://invader.dbs.umt.edu**) and INVADERS forWindows interfaces allow users to easily query the database. Outputs

include county resolution presence/absence maps, time sequenced spread maps, expansion rate curves, and regional lists of exotic flora. More detailed analyses of record locale statements and data on associated vegetation are used to predict which habitats are susceptible to invasion by individual exotic species. Locale statements can be ported to GIS to develop bioclimatic envelopes and predict potential maximum ranges for invasive species.

The outputs from the INVADERS Database have practical applications for both Weed Management Area plans and regional-scale (multi state +) management programs. These data provide the basis for risk assessment, identification of susceptible habitats, rapid response, and strategic planning.

The INVADERS database structures and user interfaces were designed to be expandable to include other states or provide a national scale invasive plant database. A National INVADERS Database on the Internet would have several important advantages over a Windows PC version.

1) The web site allows universal access to the data.

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INTRODUCTION and OVERVIEW

Some Overview Statistics from INVADERS Database Project

The INVADERS software is a computerized catalogue of plant names and an enhanced historic atlas of weed distribution data. The custom software interfaces are designed for ease of use and might be considered to be companions to *Weeds of the West*. The software runs under Windows 3.x, 95, NT, and the WEB. A DOS version of INVADERS is also available.

Over 80,000 distribution records have been collected and put into the database for the current five state region (WA, OR, ID, MT, WY). The most recent update to the INVADERS Database was Release 6.4 (May 1997). Some summary statistics of information in or calculated from the database follow:

- 8,762 plant names for 5,913 exotic and native species found in the 5 state project area (WA, OR, ID, MT, WY).
- 1,312 exotic plant names for 996 exotic species.

- 900 sensitive, threatened, or endangered plant species
- 16% of the plant species established outside of horticultural settings are exotic to North America.
- 80,017 distribution records covering 855 exotic species, and most weedy natives
- The distribution data spans 1875-1996 and was collected from the following sources:

  Dept of Agriculture, MT, OR, WY
  USFS R01 ECODATA
  Extension Service, ID, MT, OR, WA
  F. Forcella study
  U. of Idaho, Collection of Forestry (Moscow)
  U. of Idaho herbarium (Moscow)
  Madrono journal
  U. of Montana Herbarium (Missoula)
  Montana State U. Herbarium (Bozeman)
  Montana Natural Heritage Program (Helena)
  U. of Oregon Herbarium (Eugene)
  Oregon State U. Herbarium (Corvallis)
  Region 6 ecology plot data
  Rocky Mountain Herbarium, U. of Wyoming (Laramie)
  Rich Old extension records
  Roger Sheley (MSU) 10/17/94 Weed Book draft
  R. Sheley 1994 targeted weed survey data
  Mike (Sherm) Karl Columbia River Basin 1995 weed survey data
  U. of British Columbia herbarium (Vancouver)
  Whitman College herbarium (Walla Walla, WA)
  Willamette U. herbarium (Salem, OR)
  Dept. of Forestry & Range Mgmt., WSU (Pullman)
  Washington State U. herbarium (Pullman)
  U. of Washington herbarium (Seattle)
  Western Washington U. herbarium (Bellingham)

- 206 species declared noxious by state or federal governments (112 on state lists, the additional 94 are on only the federal list and not established in the region).
- 1.8% of the northwest flora are noxious.
- 11% of the introduced exotics are noxious.
- The number of exotics documented as established in each state are:

Washington	633	Oregon	580
Idaho	428	Montana	485
Wyoming	217		

Overall Purpose of the INVADERS Software/Database Project

Provide weed regulatory and natural resource management agencies with an up dateable database and data management software to support **proactive** weed management **strategies**. Determine which alien weeds are most rapidly spreading over a multi-state region before they cause severe economic losses and environmental damage requiring perpetual control over large geographic areas.

Our present system for building awareness of potentially serious new weeds among professional vegetation managers, teaching identification of new weeds, regulatory listing, and developing control strategies for alien weeds is fundamentally reactive. We typically do not know which new exotics should be considered for active monitoring and aggressive management until the geographic extent and abundance of the invader requires perpetual control of that weed over large areas of a state or multi-state region.

Not developing pro-active weed management strategies increases the costs of vegetation management by many orders of magnitude. We do not react until the degraded cumulative acreage is very large.

The INVADERS software is not another Geographic Information System. GIS is the appropriate tactical tool if you need to map the boundaries of a specific weed infestation and relate that infestation to topographic or environmental features. However, GIS requires high end computer hardware, has a steep learning curve, very high data costs, and usually requires a specialized support staff. Strategic planning does not require GIS levels of detail. In fact, excessive details may impede strategic planning.

INVADERS is a strategic weed management tool. It is designed to support programmatic decision making. It allows vegetation program managers to view distribution data showing regional scale weed spread patterns over long time periods. INVADERS is very easy to learn, uses historic data with low spatial resolution (county presence or absence), and has very low costs for the end user.

Design Goals

The primary design goal of INVADERS software/database project is to create a practical and easy to use tool for managers of vegetation/weed programs. It is intended for natural resource program managers that do not have the time to learn to use complicated software packages - it was not designed for computer experts. The software features to meet that goal include:

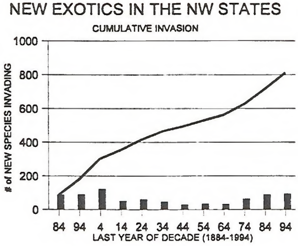
- Ease of use: learning time is less than 20 minutes.

- Will run on entry level personal computers.
- You can query the database using any published name for the weed, including Weed Science Society of America common names.
- Simplify nomenclature questions by linking old scientific names (synonyms) to the currently accepted scientific name.
- Automatic spell checking for plant and county names.
- Database includes all plants, tells whether plant is exotic or native.
- Shows regulatory status of the plant: noxious weed or whether the plant is on a protected/sensitive species list.

SCIENTIFIC MANAGEMENT RATIONALE

The exotic plant invasion phenomenon consists of thousands of exotics being continuously introduced to North America from portions of other continents that have similar climatic conditions. As of this time approximately one thousand alien plants have successfully established in wild settings in the five northwest states. After initial colonization, often at several locations, these species take several decades to a century or longer to expand to their maximum geographic range. The spatial scales can be a portion of a single state to multi-state regions, and almost all of North America for the weeds with the broadest ecological amplitude. The Flora of North America project estimates that there are 3,709 exotics among the 21,701 species that exist outside of horticultural settings in North America. (Kartesz 1998, personal communication). Strategic management of the invasion process will require an epidemiological database and the analysis of a multitude of species over large geographic regions and long time scales. The INVADERS Database was designed for these purposes. The National Strategy for Invasive Plant Management (Pulling Together) formally recognizes the need to "Expand and improve systems for detecting, reporting, and monitoring new infestations of invasive plants", "establish a national network .... to report new invasive plant infestations", and have "a central repository for this information, making it available on the Internet.." (Objective 1.2-).

A summary analysis of INVADERS Database Release 6.3 indicated that prior to 1910, during a period of little regulation of the importation of goods and agricultural commerce, about one hundred exotics per decade were establishing in the five northwest states. During the period of World War I , the Great Depression, and World War II, the number of successful introductions declined to about 40 species per decade. With the expansion of global travel and commerce since the 1950's the number of new introductions is again approaching the pre-twentieth century rate despite the enactment of numerous regulatory mechanisms.

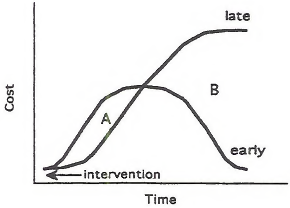


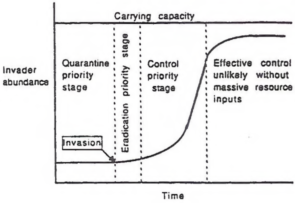
Most exotic weeds currently in North America originated from climatically similar areas of Europe, the Mediterranean Basin, and west Asia. As the global economy and trade expands in the next century we can expect to see a new wave of introductions from other climatically analogous regions including northern China, the South African grasslands, and the pampas of South America (see Mack 1996, Rejmanek 1996, Reichard and Hamilton 1997, others). Forcella and Harvey (1983) used county presence / absence data to analyze the number of exotic weed species and their relative abundance in the Pacific Northwest region from 1900 to 1980. They concluded that the steady increase in number of species and increasing relative abundance of exotics in the regional flora indicated that our longstanding weed control policies and practices where ineffective in abating the invasion process.

The role of government in management of the invasion phenomenon must differ from that of individual landowners. Some agencies, particularly in the western United States, are also "landowners" that manage specific tracts of public land, but agencies have responsibility beyond the individual tracts. Within the boundaries of a single track of land the owner-manager makes an agronomic decision as to what density of a weed can be tolerated and what threshold justifies control. Spread is the movement of the weed across ownership boundaries and the infestation of new sites. The thresholds that trigger deployment of counter measures by government to prevent spread must be lower than the agronomic thresholds for single tracts (Auld et al. 1978).

Intervention to prevent spread, if not eradicate founder colonies, must be initiated at an early phase in the invasion process (Hobbs and Humphries 1995). Late intervention results in the more successful weeds becoming permanent members of the flora over large geographic regions. The total cost of control plus the negative economic and environmental impacts are much higher for late intervention. Furthermore the annual costs of late intervention continue indefinitely into the future. As a weed spreads throughout its potential geographic range and finally approaches the carrying capacity of the new region, the invasion process can be seen as consisting of four stages, each requiring a different strategic approach to management (see figure below).

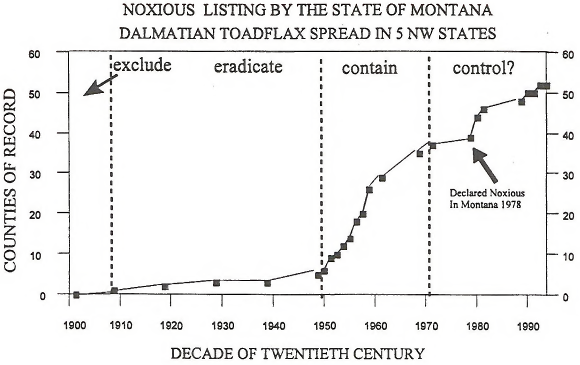
If regulatory exclusion is unsuccessful and a new area is colonized, the weed usually exhibits a lag phase during which eradication may be feasible. Once the weed begins to spread at an exponential rate management strategy shifts to controls that might allow suppression of the target species throughout it range. These include development and distribution of insect and plant disease agents and coordinated IPM programs. As the most successful weeds, such as spotted knapweed and leafy spurge, approach the carrying capacity of their new environments we begin to question the effectiveness of control efforts even with massive resource inputs.





The graph on the left shows the total social cost of a weed invasion (incorporating the costs of damage due to the invasion and the costs of control) in relation to the timing of intervention (early versus late). Initial expenditures are higher for early intervention (area A), but relative net benefits of early intervention accrue with time (area B). The graph on the right depicts phases of weed invasion and priorities for action at each phase. Ease of treatment of an invasion problem declines from left to right (from Hobbs and Humphries 1995).

Noxious is a matter of legal designation by a authorized body. Most weeds are declared noxious as the result of a consensus building process. Under our current system an organized and dedicated group concerned about a particular weed usually takes the initiative to petition the rule-making authority to list their target species as noxious. However, obtaining consensus requires that the weed be well known at least among a majority of vegetation managers, agency personnel, and political decision makers. This common knowledge is typically realized only after the weed has become very widespread and is co-dominant if not dominant over large areas. Exclusion, eradication, or containment are no longer possible by the time most weeds have become a target of agency efforts. The exotic is now "naturalized" and a permanent member of the flora over large geographic regions. Managers are logically forced to direct most control resources onto a limited number of high priority sites. Using actual data from the INVADERS Database for the temporal spread of Dalmatian toadflax from county to county in the northwest states, and the year of noxious listing by the State of Montana, illustrates the typical stage of invasion at the time of noxious listing and subsequent regulatory activity.



Strategic weed management can be summarized as having the nine sequential elements listed below. Each element is enacted at increasing orders of magnitude in costs. The INVADERS Database has utility at the first five steps.

1. Professional Awareness
2. Prevention / Exclusion / Quarantine
3. Early Detection
4. Containment
5. Noxious Listing
6. Public Education
7. Large Scale Control Commitments
8. Areal Mapping by Agencies
9. Enactment of Alternative Land Management

Alternative land management is the ultimate and highest cost strategy. It requires changing our expectation of how we utilize the land. The economic, environmental, and social costs can be huge. One example of alternative land use is to cease cattle ranching in eastern Montana and the western Dakotas because of leafy spurge dominance of rangelands, and replace that way of life with a sheep industry.

The INVADERS Database consists of point data for weed locations rather than areal (polygon) data. Point data provides a number of significant advantages for early detection and strategic planning.

- The **number** of new colonies increases much faster than acreage.
- Historic data is almost entirely point data.
- Collecting and processing point data is far less expensive than polygon data.
- Point data is obtained much more quickly than polygon data, and allow rapid response.
- Point data allows tracking of thousands of species.

The concept that the number of new infestation increases at a faster rate than the acreage is widely accepted among weed scientists. This principle underlies most models of weed spread (Moody and Mack 1988, Auld et al. 1978), although these models are usually employed to estimate cumulative acreage infested. This principle leads managers to prioritize control of satellite colonies before attacking larger founder populations. A similar realization is applied to the suppression of wildfire. When data is available for both the number of colonies and acreage over time it confirms that number of infestations increase rapidly before the increase in cumulative acreage (Braithwaite et al. 1989, Lonsdale 1993).

The temporal component of spread is as important as the spatial distribution. Historic distribution information is almost entirely point data. Point data is obtained at minimal cost in contrast to the expense of mapping the changing boundaries of weed infestations; and because point data can be obtained and processed rapidly it is particularly useful for an early detection system. Point data is the only feasible basis for tracking the thousands of exotics that have already established in North America.

A single county suffices as a point on a multi-state, regional, or national scale. The five northwest states consist of 199 counties or points. The lower 48 states consist of 3,052 counties. Herbarium collections are based on county of record. This level of spatial resolution is available with high constancy for most data sources on weed distribution. A strategic management database with three thousand cells would provide a powerful analytic tool.

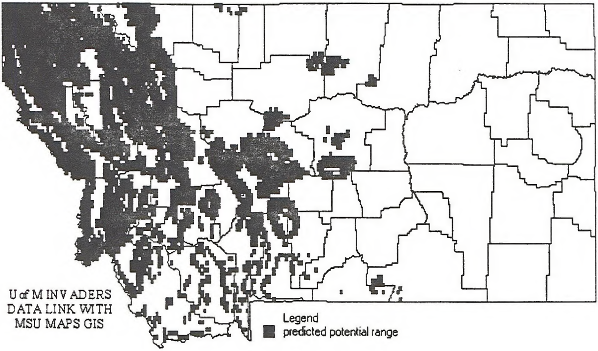
Adjacent counties could be aggregated to units with similar ecological and physiographic characters for broader scale assessment. Analysis at finer scale resolution can be conducted for special projects for priority problem plants by utilizing the locale statement in the INVADERS Database. The locale statement can be a geo-coordinate such as latitude and longitude or township, range and section. Geo-coordinates appear at low constancy in available data.

However, most records contain a place name as a locale statement. Any place name (town, physiographic feature, etc) printed on a USGS topographic map can be used to obtain latitude and longitude from the USGS Place Names database. This allows the INVADERS Database to link with any number of Geographic Information Systems. Known distribution points can then be used to establish the climatic and land use parameters associated with the reported geographic range and then predict the potential maximum range for individual weed species.

Bioclimatic Envelope for Rush Skeletonweed From INVADERS Link With MAPS GIS

Parameter	Min.	Max.	Median	Mean (St. Dev.)
Day-degrees May-Oct (40F Base)	1400	3300	2800	2,766 (308)
Avg. ann. Potential evaporation (in.)	15.4	22.8	20.6	20.4 (1.2)
Mean annual precipitation (in.)	17	90	25	33.8 (14.7)
Mean precipitation in July (in)	1.2	5.5	1.5	1.9 (0.86)
Mean temperature in July (F)	49	63	61	60.2 (2.6)
Mean temperature in January (F)	11	26	22	22.1 (2.2)

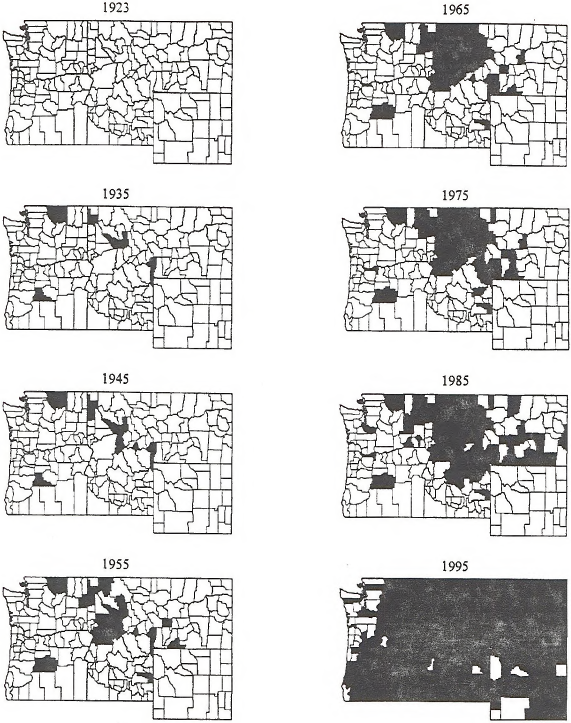
Predicted Maximum Potential Range of Rush Skeletonweed in Montana



Forcella has provided a number of examples of the utility of point data for analyzing the broad scale spread of weeds. Historic county presence / absence records were the raw data. His work during the early nineteen eighties provided the inspiration for the INVADERS Database Project. Forcella and Harvey (1988) used principle coordinates analysis to identified four strong spatial spread patterns for weeds that had been introduced to the Pacific northwest states prior to or near the turn of the century. A number of old weed species established before nineteen hundred at west coast shipping ports then moved eastward into the interior. Other weeds were first introduced during the period of the settlement of the prairies of eastern Montana and Wyoming by small tract homesteaders. These disturbance-adapted weeds moved from east to west.

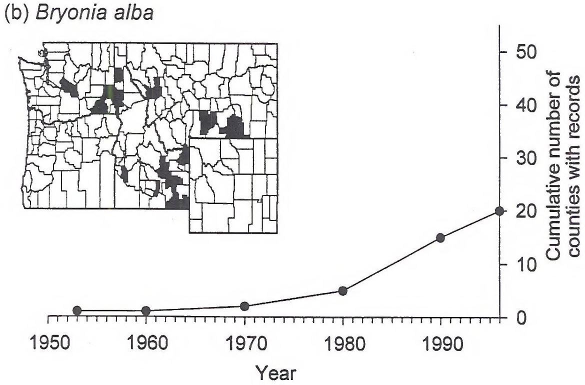
The INVADERS Database allows the user to create time sequenced distribution maps to examine patterns of spread. New regulatory strategies to restrict spread can be developed if spread patterns of more recent and modern periods can be identified. In-place regulatory activities such as the weed seed free forage certification program and closures can be refined.

What are some of the more recent spread patterns? A number of invasive species have built core populations in the inter-montane valleys and low to mid elevation forest of the Northern Rockies during the mid part of this century. They have then spread outward from western Montana or northern Idaho to infest much of the northwest. Spotted knapweed, sulfur cinquefoil (Potentilla recta) , orange and meadow hawkweeds (Hieracium aurantiacum and H. pratense) are examples of weeds which have recently spread to or nearly reached their maximum potential range. Their pattern of spread is a phalanx (sensu Wilson and Lee 1989) moving as a wave from one county to the next.



Counties reporting *Centaurea maculosa* infestations during 1925-1995 in Washington, Oregon, Idaho, Montana and Wyoming.

The most recent invaders often have a pattern of county presence / absence that appears to be at first random. It is in fact a random long distance dispersal to widely separated counties followed by nearly simultaneous shorter distance dispersal to adjacent counties. Wilson and Lee (1989) call this "infiltration" spread. White bryony (*Bryonia alba*), the first Pacific Northwest record being in 1953, exhibits an infiltration pattern. This riparian zone invader has a berry-like fruit that is carried over long distances by migratory birds, then spread about those initial colonies by a number of shorter distance transport mechanisms. However most of the random long distance dispersal mechanisms are anthropogenic. These include orders from seed and nursery stock catalogues, oil drilling rigs and logging equipment, wild fire suppression, hunters, boaters, and other recreational travelers.



Planning appropriate strategic responses to individual invaders is facilitated by considering temporal expansion curves based on the cumulative number of counties reporting initial infestation as a function of the year of record. The INVADERS software can plot these data and calculate the best fit polynomial regression to the third degree. The temporal expansion curves can be grouped in five useful classes, which in consideration with their spatial pattern, might suggest appropriate strategic responses. The following suggested strategies are for illustration of the planning concepts, not to the exclusion of other appropriate strategies.

1. Hyperbolic	limited distribution weeds and non-weedy natives
response: tolerate	
2. Near Linear	old weeds
response: develop biocontrols, change land use !	
3. Logistic (S-Curve)	slow start, rapid mid-phase, now slow
response: modify management and enact controls only for high priority sites	
4. Exponential	rapid expansion into region
response: aggressive regional IPM programs, start biocontrol development?	
5. Early Exponential	recent invaders beginning rapid expansion
response: professional awareness, detection, aggressive herbicides and/or mechanical	

Graphic plots of county by first year of record for exotics with limited ecological amplitude form a hyperbolic curve with a small number of total counties infested. Their habitat and climatic requirements are only matched in a small part of the region. Swainsonpea (*Sphaerophysa salsula*) is an example. It has been reported for 12 counties with only one new county since 1961. Graphs for native (non-weedy) species like scarlet gilia or bluebunch wheatgrass are strongly hyperbolic although the total number of counties can cover a large portion of the region analyzed. Most natives have not increased their range significantly during recent historic times. Some weedy natives, like indigobush (*Amorpha fruticosa*), do have exponential expansion curves in this century, but they are typically being introduced into a new geographic sub-region of the continent, and often are of concern to wildlife and vegetation managers. Hyperbolic weeds may be monitored for future spread, but the regional and national strategy would be to tolerate the species although it may be problematic within its limited range.

Old weeds, introduced near the turn of the century, with broad ecological amplitude and often well adapted to disturbance habitats, often exhibit near linear plots. They have reached or nearly reached their maximum range which is almost the entire region. Hoary cress (*Cardaria draba*) is an example of an "old weed" that has occupied almost every county in the five northwest states. If one plots just the early decades of invasion by a now linear plot old weed the best fit regression for the early period will be exponential and reveal both the lag phase and the period of rapid expansion. Forcella (1985) has demonstrated that the species which have the

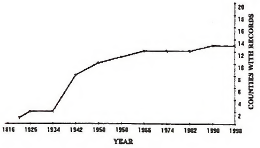
highest initial rates of expansion most often are those that eventually occupy the largest geographic range. Suppression is the only feasible management goal for linear plot weeds and strategies must include the development of biocontrols. Some of these linear exotics are so abundant within their large geographic range that we are forced to reevaluate our expectations for use of that land.

Logistic or S-curves plots reveal the classic invasive species expansion. Western salsify and bladder campion are examples. Depending on the species, the transition from the lag phase to the rapid mid-phase may be the result of intrinsic population dynamics such as acclimation or reaching critical reproductive mass, changes in land use patterns that create new disturbance habitats, human development of new modes or routes of transport, and several other causal factors. Nonetheless, as the species expansion slows again the weed is now so widespread that land managers must consider a strategy that prioritizes individual sites in order to allocate limited control resources for use on only the highest value sites. Bladder campion (*Silene vulgaris*) is an example of a moist disturbance environment weed that went into a rapid expansion phase starting in the 1950's. Rural electrification made it possible to develop irrigated alfalfa as a cash crop in western Montana and Northern Idaho, but by the late seventies the cost of pumping and limited water began to restrict the expansion of susceptible habitat for this weed.

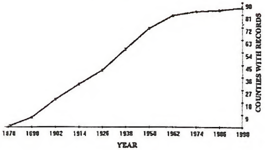
Strategic intervention during the exponential phase requires the development and aggressive implementation of regional-scale integrated weed management programs. National and regional scale managers need to consider starting the biological control agent screening process and obtaining approval for introductions. Initiation of coordination between managers of federal agencies and infested states, and pooling of resources is critical. Delaying the coordinated response for another decade at this stage will insure that the weed becomes a widespread and often excessively abundant. Purple loosestrife (*Lythrum salicaria*) data provides an example of a strongly exponential temporal expansion curve for the northwest region.

The opportunity for cost effective government intervention is realized by recognizing and acting on early exponentials like white bryony. These new invaders have recently exited the lag phase and begun exponential spread. Strategies must start with professional awareness and the ability to recognize these species in the field before the new colonies can obtain the density and areal extent that allow them to generate ever more numerous satellite colonies. Only early detection will allow the possibility of containment if not eradication. Aggressive use of existing management tools, particularly herbicides and/or mechanical controls, will often suffice at this stage.

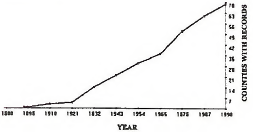
HYPERBOLIC (Limited Range) Swainsonpea



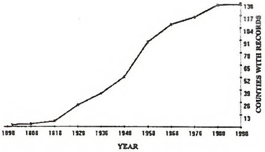
NATIVE Scarlet Gilia



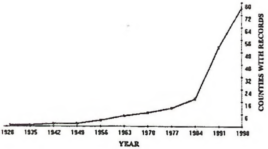
Near Linear Pattern - Whitetop or Hoary cress
Usually "Old Weeds"



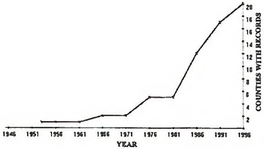
LOGISTIC - Western salsify



EXPONENTIAL Purple loosestrife



EARLY EXPONENTIAL White bryony



Five Archetype Temporal Expansion Curves for Exotics (and One Non-Weedy Native) in the Pacific Northwest States (Note: the plotted scales for the year and number of counties vary)

Do early detection strategies actually work? The INVADERS Database has numerous similarities to a disease registry and it epidemiological uses. However, unlike the epidemiologic study of human disease and medicine, the relatively low data density for weeds and the duration of treatments being multiple decades preclude statistically testing of the effectiveness of early intervention strategies. Only a limited number of case histories can be presented to confirm the reasonableness of these strategies.

There are no extant populations of yellow starthistle in Montana although it is widely distributed and exceedingly abundant in the adjacent western states. Yellow starthistle is a Category 3 noxious weed under Montana state law. Category 3 weeds are new invaders, weeds not yet detected in the state or found only in small localized infestations. Awareness and education, early detection, and immediate action to eradicate are mandated by the state noxious weed act. A bioclimatic analysis linking the INVADERS Database with the Montana Agriculture Potential System (MAPS) indicates that 30% of Montana has climatic conditions that would support yellow starthistle. Most professional vegetation managers in Montana have some awareness of this species. In fact there have been 11 reported introductions of yellow starthistle in Montana in the past 15 years. All were detected within a year or two of suspected introduction and eradicated while the number of plants and acreage covered was small.

<u>Some Types of Practical Planning Uses of the INVADERS Database</u>

- Each local level agency weed manager can generate area specific list of exotic plants for their county, approximate area, district, or forest

- Generate an "Alert List" of recently introduced weeds that are spreading rapidly across the region. An early warning list is an essential prerequisite for pro-active management.

- Determine which new weeds need to be included in ID training programs and bulletins, and where training efforts for established weeds need to be increased.

- Determine which habitats are susceptible to invasion by specific exotics as part of the risk assessment for weed control EIS's and management plans; prioritize inventory and mapping efforts.

- Program can detect where a weed came from by plotting regional scale distribution patterns for sequential time intervals. Crop and Weed Seed Free Forage field inspection, vehicle cleaning, and other regulatory actions could be used to reduce the transport of noxious weed seeds to new areas.

- Graphic plots of the cumulative number of counties reporting a weed over the year of the report combined with maps of the reported distribution suggest what type of regional scale strategic management might be most appropriate for that weed.

- Import locale statements from known distribution records to GIS and predict potential maximum range expansion for similar climatic and land use conditions.

- Spread pattern plots, maps, and summary statistics and graphics derived from the database could be use to illustrate the extent and severity of the invasion process to lay decision makers who make budgetary and policy decisions.

- A shared database on weed distributions and spread rates could reduce the political aspects of listing weeds as noxious.

- Distribution maps help identify possible multi-agency cooperators for weed management projects.

Some Recent Applications of INVADERS Database by Land Managers

1. Weed Seed Free Forage Program: A Regional Scale Prevention Program

To support a regional scale management program the INVADERS Database was queried for the known Montana distribution records of the 52 weed species in the Weed Seed Free Forage Program. A total of 4,833 records for 44 species were available and 3,021 records had locale statements (geocoordinates, legal descriptions, place names) sufficient to obtain latitude and longitude. These weed occurrence records were used to extract selected climate and physiographic parameters from the statewide MAPS database and geographic information system. MAPS contains data on land and climate attributes for each of 18,000 eight-square-mile cells in Montana. These estimates were used to provide a description of the climate associated with the current known distributions of each weed species in Montana. For 27 species that had >15 usable distribution records, predictions of potential maximum ranges in Montana were made by mapping the climate descriptions into geographic space using the MAPS Atlas. The predicted current range and predicted maximum range maps can be used to:

- Improve the search and identification skills of field certification inspectors.
- Inform producers as to which weeds they should be particularly familiar with to prevent infestation of their certified crop fields.

2. Columbia River Basin Ecosystem: A Regional Scale Weed Infestation Risk Assessment

A risk assessment was conducted to determine the susceptibility of vegetation cover types to 206 taxa on the federal and states noxious weed lists. Eighty-four cover types were used to characterize the multi-state regional vegetation based on Society of American Foresters (SAF), Society of Range Management (SRM), and Columbia River Basin (CRB) specific cover types. Each cover type was rated for susceptibility to invasion by the individual weeds:

D = "Disturbed": Weed species is successful because high intensity or frequency of disturbance impacts the soil surface or removes the normal canopy cover.

I = "Invasive": Weed species can obtain dominance or co-dominance even in the absence of intense or frequent disturbance.

C = "Closed": Cover type does not provide a suitable habitat for the weed species.

Agency staff used cover type, precipitation, and land ownership attributes in the CRB project GIS (one square kilometer resolution) to calculate the hectares and percentage of the multi-state ecosystem susceptible to selected weeds. They generated maps showing regional scale infestation risk at low, moderate, and high levels. As an example it was concluded that 27% or 39 million acres of the Columbia River Basin are highly susceptible to spotted knapweed, and 14% or 20 million acres are at high risk of infestation by yellow starthistle.

<u>3. Alert List for the Blackfoot Challenge Weed Management Area</u>: One of Four BLM Demonstration WMA's

The goal was to identify problem plants early in the invasion process. The INVADERS Database was queried for all the exotic species in the two counties encompassing the Blackfoot River drainage and all nine counties contiguous with those two. The exotic flora of this multi-county infiltration area consisted of 387 species. The rate of spread of each species throughout the larger multi-state area was plotted to identify those in early stages of spread. Ancillary tables in the INVADERS Database were then queried to determine which species were already included on state, national, and international lists of problem and noxious plants. The original 387 exotics were prioritized to form two short lists. One was a "dirty dozen" of well known noxious weeds that are not yet well established in the Blackfoot WMA. The second was an "alert list" of thirty less well known weeds that have the potential to become significant problems in the WMA over the next fifty years. An analysis of invasion susceptibility and risk rating was completed for six coarse scale environmental types (agricultural, grasslands, forest, riparian, wetlands, and disturbed areas) for each alert list weed. Over the next six years the Blackfoot WMA should implement the dirty dozen and alert lists according to the following schedule as part of their management efforts.

ANNUAL SCHEDULE FOR BLACKFOOT WMA
EARLY DETECTION & PREVENTION PROGRAM

	1997	1998	1999	2000	2001	2002
Alert List						
Environments						
ID Training						
Recon & Map						
Tactics						
Control						
Monitor						

<u>4. Tally Lake Ranger District Tansy Ragwort Project</u>: EIS and WMA Planning Process

A large wildfire was followed by the outbreak of the second and the largest infestation of tansy ragwort in Montana. Regression coefficients from the INVADERS best fit temporal

expansion curve were used to project the potential future regional spread of tansy ragwort with and without an aggressive containment action. An INVADERS database infestation susceptibility matrix at habitat type resolution was used to estimate cut over and forested acres at risk under the EIS's No Action alternative. The Proposed Action included helicopter and ground spraying of herbicides, road and area closures, and test releases of biological controls as parts of an IPM strategy. The tansy ragwort maps and spread projections were used to inform the public of the problem, to secure working agency and private sector partners, and obtain cooperative funding for the WMA. The EIS was completed and the Proposed Action accepted within nine months. The rapid completion and acceptance allowed large block herbicide applications to be made in the first growing season after starting the planning process. The habitat type risk ratings are being used in the second year to set priorities for control actions and inventory the larger area for satellite tansy ragwort colonies.

Potential User Group

Every vegetation program manager from county weed supervisor to the Federal land manager should have a copy of the INVADERS software on their computer and/or be accessing the INVADERS web site. The potential users include the following:

- County Weed Control Departments
- State Departments of Agriculture - Weed Coordinator
- State Extension Service - Noxious Weed Specialist
- State Land Departments
- State Fish, Wildlife, and Parks Departments
- US Forest Service
  - Regional Office -
    - Range Implementation Director
    - Pesticide Coordinators
  - Forest Supervisor Offices - Forest Planners and EIS Team Leaders
  - Ranger Districts - Weed Program Leader
- Bureau of Land Management
  - BLM State Offices - Weed Scientist
  - BLM Area Offices - Conservationist
- Bureau of Reclamation
- USDA Agricultural Plant Health Inspection Service - State Officer in Charge
- USDA Agricultural Research Service - Weed Biocontrol Researchers
- Federal Fish & Wildlife Service
- National Park Service
- University Faculty with -
  - Courses on invasive plants, range management, & biological conservation
- Herbicide Companies
- Conservation Agencies and Foundations

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BLM Weed Page

National Weed Symposium

April 8-10, 1998

ABSTRACTS

TANSY RAGWORT CONTROL: A MANAGEMENT APPLICATION OF THE INVADERS DATABASE

Cathy Calloway, Flathead National Forest, Whitefish, Montana

Following a wildfire in 1994, the Tally Lake Ranger District in Northwestern Montana experienced a population explosion of Senecio jacobaea or tansy ragwort. This was only the second, and by far the largest infestation of this invasive weed in the state of Montana.

Information derived from the Invaders Database was used to project the potential regional spread of tansy ragwort without management action. Historical records dating back to 1901 were used to project the likely future expansion of tansy ragwort within the five northwestern states. At a more local scale, with information from the Invaders Database and other sources, Dr. Rice was able to provide the Project Interdisciplinary Team with a tansy ragwort risk rating for disturbed and forested site conditions. This ranking of habitat type susceptibility to tansy ragwort was used in the project Environmental Impact Statement (EIS) to quantify the risk of spread of tansy ragwort for the No Action alternative.

A clear depiction of the likely progression of tansy ragwort and the resources potentially at risk was instrumental in demonstrating the need for aggressive and immediate Forest Service action to address the infestation. As with many government actions, gaining the local publicþs belief in the purpose and need for action was a vital step in completing the environmental analysis and documentation necessary to implement an integrated control strategy. In a nine month period in 1996-97, an EIS was prepared to authorize aerial and hand spraying, road management actions, and testing of biological control.

An understanding of the potential spread of tansy ragwort has also been important to successful development of a variety of strong partnerships and acquisition of cooperative funding over the last year and a half.

One important component of the on-going control strategy is continued inventory to assess the extent of further spread. The habitat type risk ratings, based on the Invaders Database, are being used to help set priorities for 1998 inventory efforts.

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TANSY RAGWORT CONTROL: A MANAGEMENT APPLICATION OF THE INVADERS DATABASE

Introduction

I am glad to get the opportunity to attend this session and share with you the Tally Lake Ranger District's experience in dealing with a new noxious weed invasion. Unlike many of the speakers you'll hear from during the next several days, I'm a newcomer to noxious weed management. I'm a silviculturist, not a weed scientist. Whatever knowledge I have has been developed "on the fly" and of necessity! But I think that the District's specific experience with one specific weed problem will illustrate many of the broader issues we're here to discuss.

Two years ago my district had no noxious weed control program or budget. For the last two years we've been on a very rapid learning curve in developing an integrated control program from ground zero to deal with a new invader after a large wildfire. We've learned a tremendous amount about weed biology, control options, inventory, staffing and equipment, partnerships and grants. In less than two years time, my District's program has built to more than $300,000 spent on control efforts for a single weed species – tansy ragwort. And we anticipate, with our partners, the need to spend similar amounts this year and into the future. It's certainly been an education.

The project I'm going to discuss is on the Tally Lake Ranger District of the Flathead National Forest. We're located in Northwestern Montana, approximately 50 miles from the Canadian border, not far from Glacier National Park.

History of the Infestation

Tansy ragwort (Senicio jacobaea L.) is a Eurasian weed, brought by ship into Klikatat County, Oregon near the turn of the century. Its an aggressive invader of disturbed sites, including irrigated and non-irrigated pasturelands, and cutover forests. Tansy can effectively displace native vegetation. All parts of the plant are toxic to livestock. Since its arrival in North America, it has been a serious ecological and economic threat in the Pacific Northwest.

By the early 1940's, tansy had spread to eight counties west of the Cascade Mountains in Oregon and Washington. Since that time, the spread of tansy has accelerated, impacting Eastern Oregon and Washington. Tansy was first identified in Western Montana on a harvested area of private forest land in 1979. The second population of tansy ragwort in the state of Montana was identified on the Tally Lake Ranger District in 1993 by a Forest Service employee with a particular interest in botany. He found three or four small clumps of tansy in old harvest units in one localized area. At that time, we knew very little about the species. We consulted with

botanists at the University of Montana to confirm the identification, and treated the plants by hand pulling. We visited the same sites again in 1994, found little spread, and again hand pulled the plants.

In the summer and fall of 1994, the west had a very big fire season. In August of that year, a lightning-caused wildfire started on a neighboring District. The Little Wolf Fire eventually burned onto the Tally Lake District and spread to a total size of 15,000 acres before the fire was contained. The Little Wolf fire burned through a managed forest landscape including mature stands of lodgepole pine and mixed species stands including western larch, Douglas-fir, lodgepole pine, Engelmann spruce and subalpine fir. The landscape also included many seedling and sapling stands.

The intensity of the fire varied greatly. Much of the mature forest burned with a high-intensity, stand-replacing fire, with a limited number of surviving Douglas-fir and western larch. Some areas, particularly riparian bottoms and some northerly slopes burned with a low intensity underburn which resulted in limited immediate tree mortality, although the stress of the fire lead to a variety of insect and disease problems over the next several years.

So, what did all this mean to the tansy populations? In 1995, the District was busy with consideration of fire salvage, rehabilitation, and regeneration assessments for the fire area. At that time, we didn't know anything about the response of tansy ragwort to fire. Casual surveys, and a series of post-fire succession plots did not identify a major spread of tansy within the burned area. Nor were any flowering plants found that summer.

I need to explain that tansy ragwort is generally a biennial. It can germinate both spring and fall, and in the first year forms a fairly low-lying rosette. In the second year, it puts up a 2 to 4 foot flower stalk, and has a showy yellow flower head. In 1996, the second growing season after the fire, we found a very different situation. We identified several very high density sites within burned openings in the fire area, and by July we knew that we were facing a pretty dramatic spread of tansy within the burned area. There were many flowering plants at numerous new locations. At that point we began to do more systematic surveys to get an idea of the extent of the spread.

That summer, we completed a quick Categorical Exclusion to allow herbicide spraying of roadside areas within the fire to limit the immediate spread potential. We spent the late summer and fall surveying the burned area to identify the extent of the infestation. We identified approximately 1000 acres with some level of tansy infestation within the fire perimeter, and scattered spot populations (less than five plants) along forest roads and the edges of forest openings outside the fire. At the same time we began gathering information from any and all sources to develop a treatment strategy. In the course of several field trips that fall, the consensus of the experts was that the only way to effectively deal with the infestation in this uneven forested terrain was to consider aerial spraying. Thus the Interdisciplinary Team embarked on the preparation of an Environmental Impact Statement, as required by Forest Service policy.

Use of the INVADERS Database

So how did we use the INVADERS Database to support the District efforts? First, we used the information provided in the database to assess the broad scale threat of expansion of tansy. The

INVADERS database, with herbarium records dating to before 1900, provided the historical context for how tansy has spread from west to east over the last century.

The INVADERS software provides spread progression maps in a variety of formats. Figure 1 displays the spread of tansy ragwort from 1901, to 1924 to 1949, and finally the present distribution which affects 38 counties in the five northwestern states. I might point out that I don't know the distribution of tansy in the rest of the country. As far as I know there is no good single source for broader distribution data, except perhaps on a state by state basis.

Using this historical data, Dr. Rice provided our project Interdisciplinary team with a projection of future spread of tansy ragwort. The "best fit" regression, based on the number of counties with tansy and the first year of occurrence for each new county, showed a clear exponential relationship. Based on the regression, he predicted that by the year 2020, an additional 14 counties could be affected. Looking at the general pattern of spread from west to east, it is likely that there will be increasing effects in Montana and Idaho. Figure 2 shows the projection.

At a more localized scale, the INVADERS data, plus other available information on tansy and similar species was used to develop a risk rating for tansy ragwort, based the presence or absence of site disturbance and forest habitat type. Areas at high risk were burned sites on cool moist to warm and dry habitats -- this was the majority of the area burned by the Little Wolf fire -- plus surrounding unburned sites in a seedling, sapling or shrub stage. A total of 26,700 acres in and adjacent to the fire area were determined to be high risk. Moderate risk sites, totaling 11,000 acres, were the wettest sites within the fire area, and cool moist sites outside the fire area without recent disturbance. A total of 31,000 acres were identified as low risk. These sites were the wettest and driest mature forest sites outside the fire perimeter.

The analysis developed based on the INVADERS database was extremely valuable in communicating with many audiences: the general public, various special interest and environmental groups, the project Interdisciplinary team, the decision-maker, and potential partners. One of our greatest challenges was gaining public support, or at least acceptance, for rapid, aggressive Forest Service action to control the burgeoning tansy ragwort infestation. Particularly since we were proposing the use of herbicides, including aerial application, we needed to have a well grounded basis for explaining the potential threat and quantifying the risk of spread both regionally and locally. This information was the foundation for analyzing the effects of the No Action Alternative in the Environmental Impact Statement, in terms of potential vegetative changes over time, and the resulting resource and economic impacts. A good understanding of the potential spread of tansy ragwort has been instrumental in on-going communication with the media and members of the public, developing strong partnerships, and pursuing cooperative funding to help jump start our control efforts in the last year.

Tansy Ragwort Control Project Status

The Environmental Impact Statement was completed in nine months and Record of Decision was signed in June 1997. With the support of the Forest Service Washington Office and the Environmental Protection Agency, we were able to expedite the review and implementation process based on the emergency nature of the project. Treatment was authorized to begin immediately after signing the decision, during the appeal period. As it turned out, it appears that intensive public education and involvement efforts were effective. Although many Forest Service

actions on the Flathead National Forest are routinely challenged, the tansy ragwort control project was not appealed.

The Decision for Tansy Ragwort Control included integrated treatment:

- Spring and fall treatment with one of three herbicides – Clopyralid or picloram in upland areas, and 2,4-D (Aquatic label) in riparian buffer strips
- Hand, roadside, and aerial application
- Testing of biocontrol agents
- Access management
- Aggressive inventory
- Education
- Monitoring

I have to take this opportunity to showcase the tremendous amount that has been accomplished with the help of numerous partners in our first year of treatment. Grant funding was provided by *Pulling Together*, a collaborative effort between the National Fish and Wildlife Foundation, Bureau of Land Management, and USDA Forest Service, designed to implement effective, long-term invasive plant management at the local level. A generous grant from the Montana Department of Agriculture Noxious Weed Trust Fund, and collaboration with the Flathead County Weed Department in implementing that grant, were also crucial to our first year efforts.

Using both Forest Service and contract crews, we hand sprayed more than 2000 acres between June and September. The vast majority of treatment was spot application of herbicide with backpack sprayers. The Flathead County Weed crew also contributed to the total effort with roadside spraying within the fire area. In October, over two days, with about six hours of helicopter time, we aerially sprayed an additional 820 acres. We believe this was the first area where tansy ragwort has been aerial sprayed. In some areas which we did not receive timely herbicide treatment, we hand clipped seedheads and disposed of them in a central burn pile to eliminate immediate seed spread.

Working with George Markin from the USDA Biological Control group, we established three separate test populations of each of three biological control agents which have been effective in Oregon: cinnabar moth larvae, ragwort seed fly and tansy ragwort flea beetle. We are anxious to get back to the sites this spring to see how the insects over-wintered in the higher elevation, harsher climates of western Montana.

In partnership with Dow Elanco, we began monitoring efforts to establish a local base of information on plant development, herbicide effectiveness, seed viability, and tansy and other vegetative response to herbicides in our local ecosystem. That effort has already revealed a few surprises which will help us improve on the effectiveness of future treatment. We also did a pilot project with the Forest Service Remote Sensing Application Center to develop technology transfer for inventory via remote sensing with digital aerial photography.

One thing we knew in the fall of 1996 was that our inventory was incomplete. At that time, none of the neighboring landowners or managers had identified tansy on their property. With better awareness and identification skills of all of our Forest Service crews, education efforts with neighboring landowners and managers and many members of the public, during the 1997 field season our estimated total acres infested across all ownerships increased dramatically to more

than 13,000 acres. We now know that two National Forests, two counties, state lands, private ranch and timber lands are all involved in the infestation. We also discovered in the past year that tansy ragwort has likely been on private land in the neighboring county for more than a decade. Isolated spot populations have been found up to 20 air miles from the Little Wolf Fire area.

Despite the large jump in inventory, we are optimistic that our rapid response efforts to date have been quite successful, and our strategy is evolving to deal with the more complex infestation we now face. For 1998, we have developed greatly expanded partnerships with Flathead and Lincoln County Weed Boards, Montana Department of Natural Resource Conservation, Plum Creek Timber Company, Burlington Northern-Santa Fe Railroad, Bonneville Power Administration, as well as several local ranchers. We have developed a Steering Committee to establish a coordinated strategy that jointly sets treatment priorities across all affected ownerships, cooperatively pursues grant funding. In the next year we hope to develop and maintain a common inventory and mapping protocol for the total infestation. We know that dealing with this situation will require a long term commitment from all of us together. We also realize that its something that must be done.

Future Application of the INVADERS Database

One of our continuing challenges is to build and maintain a more complete inventory of the infestation across all ownerships, and identify the true outer perimeter of the tansy infestation. At this point, areas known to be at risk include all 15,000 acres impacted by the wildfire, past harvest units in a seedling or sapling condition, and any newly disturbed sites, such as harvest units, roadsides, and pasturelands. That translates to a lot of acres that should be surveyed.

We're currently working on an additional way to use the risk ratings from the INVADERS database – as a way of setting priorities for future inventory efforts. To keep things simple for this illustration, I'll summarize the situation on Tally Lake Ranger District, where I have the most complete information. The same approach could also be used on other ownerships.

A query of our timber database records shows that over 50,000 acres, out of a District total of more than 230,000 acres, have had a past regeneration harvest and are now in a nonstocked, seedling or sapling condition. All of these areas are of at least moderate risk for tansy infestation, and should ultimately be inventoried. To narrow things down, we've decided to focus on stands which have been harvested from 1970 to approximately 1992. More recently harvested stands have been eliminated because they already have scheduled visits to assess reforestation progress, and tansy inventory has now been incorporated into those exams. That reduces the area to be surveyed to about 40,000 acres.

Using the site risk ratings provided by Dr. Rice and the INVADERS database, and the age of the harvest unit we have developed a risk/inventory priority rating. This rating system splits the area to be inventoried into 14,000 acres of high risk , 22,000 acres of moderately high risk, and 2,000 acres of moderate risk. Even if we just looked at the high risk areas, that's still a lot of inventory.

The last two elements which will influence our inventory priorities are distance from the main infestation in the Little Wolf Fire area, and proximity to identified tansy sites. Our current treatment strategy is to place priority on eradicating the most distant, small isolated populations first to prevent further seed spread. Second priority will be to work in from the perimeter of the main infestation, with continued aerial spraying to contain and ultimately reduce the size and

density of the main population. Thus, our inventory strategy will be to start with the high risk sites near the outermost known populations, to locate and stamp out any new populations as they are established. As our resources allow, we will continue to add to our inventory closer to the central high density infestation.

I hope by now you've gotten the clear impression that the INVADERS database has been an invaluable resource for the Tally Lake District in developing and fine-tuning our control efforts. While the applications I discussed have been specific to one weed in a localized area, I think the ideas I've suggested are also applicable to broader strategic efforts.

Management Needs

I'd like to conclude by sharing some of my ideas about broader management needs, based on our local experience with tansy ragwort.

First, I think there's a need for better early warning systems for potential new invaders, particularly after large disturbances such as fires. Perhaps a standard part of post-fire rehabilitation assessments should be a weed risk rating, and where appropriate, the design of a systematic post-fire weed survey. Another possibility is to develop regional or state "watch lists" to provide managers with pertinent information about potential new invaders. I think enough is known about patterns of spread for many particular weeds to make these suggestions feasible and potentially very effective.

For our District, it has been a real challenge to build a good map of the infestation on two adjoining National Forests. When you add in State, private and corporate lands, it gets considerably more complex. My guess is that our experience is fairly typical. I think there's a need for more uniform and accessible inventory, mapping and data storage methodologies that can be used seamlessly across ownerships, management and political jurisdictions.

In Montana we're fortunate to have the INVADERS database. I can certainly see the value of more comprehensive information on risk ratings, spread potential, and known occurrence across broader geographic areas. Mapping of potential habitat by species would be very helpful to land managers in assessing the potential risk of weed spread presented by new proposed management activities.

Coming from a district where there was no weed management program, I found that there was a very steep learning curve. There's a lot of weed science and management information out there, but it takes time to learn where to look and who to ask to get what you need. I believe we need more and better mechanisms for technology transfer between research and management. We also need more ways of networking, across agency boundaries, among managers. Sessions like this are excellent, but they don't necessarily reach the folks who will have a future need to find information quickly to deal with, or hopefully head off, a future emergency situation.

If we're serious about addressing the growing ecological threat that weeds present, I think we're going to have to invest more money and a steady supply. Grants and partnerships play a key role. But in many local areas with extensive public land ownership, the federal agencies need to step up and invest in maintaining or restoring native ecosystems. I also think that it is time that the Forest Service separate noxious weeds from range in our budgeting process. Weed control is NOT just a range issue!

Lastly, I think we need to do a better job of working with our partners to set regional priorities. We need to work together to make the hard choices about where we can collectively be most effective and successful in our control efforts. We must spend the available money wisely.

In closing, I have observed that the Tally Lake Ranger District's experience with tansy ragwort has changed the way we do business, from how we write timber sale contracts and do forest inventory, to how we deal with special use permits and road maintenance. We have certainly been convinced of the vital importance, as well as the challenges and complexities of noxious weed management. Our District team is committed to the long-term effort necessary to contain tansy ragwort, and to deal with new infestations as they arise. The success of our efforts to date, and undoubtedly our future success, will depend on nurturing strong partnerships and developing and maintaining public support. I think the same is true of our National efforts.

Attachments–

Figure 1. Spread of Tansy Ragwort in the Five Northwestern States (from INVADERS Database 6.4, 1997)

Figure 2. Historical and Projected Distribution of Tansy Ragwort in Five Northwestern States (from INVADERS Database 6.4, 1997)

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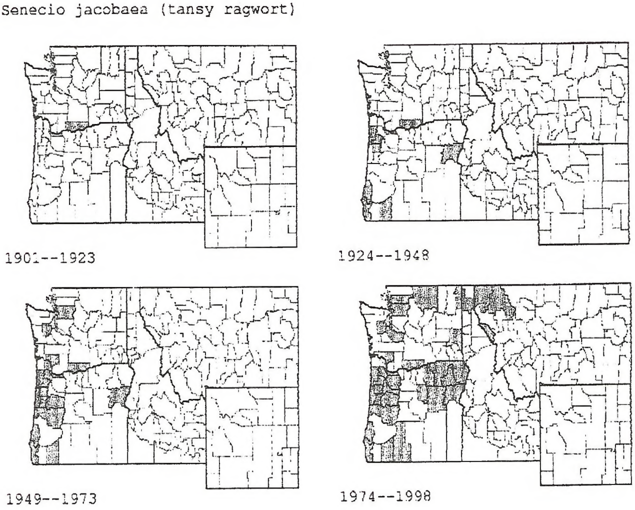
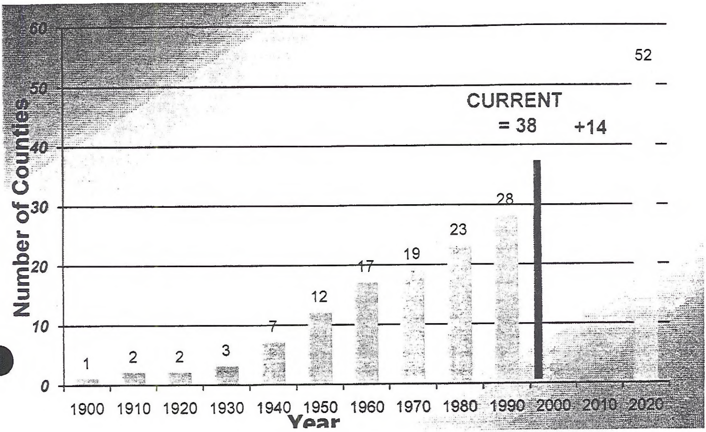
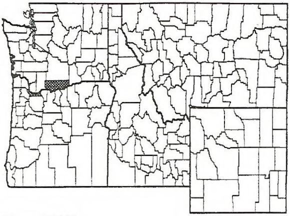


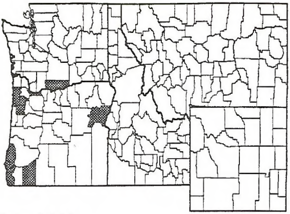
Figure 2. Historical and Projected Distribution of Tansy Ragwort in Five Northwestern States (from INVADERS Database 6.4, 1997)



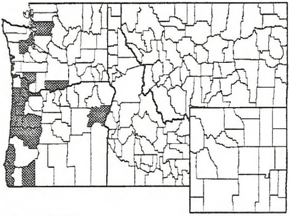
Senecio jacobaea (tansy ragwort)



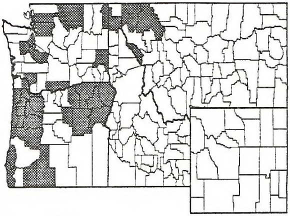
1901--1917



1918--1944



1945--1971



1972--1998

Distribution Map for 1901--1998 for the NORTHWEST region

Invaders DataBase release 6.4 (EVERY-27-YEAR map page: 1)
Peter M. Rice, University of Montana Print Date: 4/7/1998

BLM Weed Page

National Weed Symposium

April 8-10, 1998

ABSTRACTS

WHAT IS THE ROLE OF REMOTE SENSING IN LOCATING NOXIOUS WEED INFESTATIONS

Henry Lachowski, USDA Forest Service, Remote Sensing Applications Center

Effective management of noxious weeds calls for early detection and eradication before infestations become too large to handle. This requires that we know the location and size of existing and new infested areas, or that we can predict the most likely places where such infestations can start. Resource managers have been using remote sensing and associated technologies to map and monitor land cover. Data obtained from various remote sensing tools is a source of information on the location, quantity, and condition of land cover; data obtained days or years apart allows change detection and monitoring of resource base over time. Noxious weeds can be observed from various remote platforms. Successful detection and mapping depends on several factors such as the resolving power of the instrument, the topography, size of infestation, timing, and the "unique" appearance of the plants we are looking for in relation to the surrounding plants and landscape.

The Forest Service Remote Sensing Applications Center has been developing techniques for use of various remote sensing tools. In partnership with several national Forests, BLM, and Park Service personnel, we have tested several methods for mapping weeds, and for modeling areas susceptible to infestations. Data from remote sensing, and the resulting "interpreted" layer is normally stored and used in a geospatial database. Maximum benefits are derived when such data are used in conjunction with other geospatial layers and tabular information. This requires some knowledge and skill in the use of geographic information systems (GIS), positioning systems, and associated technologies. Recently completed cooperative projects demonstrate the utility and limitations of several remote sensing tools such as conventional cameras, digital cameras, and multispectral scanners. These projects point out that proper timing of aerial data collection is the most critical factor for discriminating the noxious weeds from the surrounding vegetation and other land cover.

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BLM Weed Page

National Weed Symposium

April 8-10, 1998

ABSTRACTS

DETECTING SMALL INFESTATIONS OF FOUR NOXIOUS WEEDS ALONG THE SALMON RIVER DRAINAGE IN CENTRAL IDAHO; A FEASIBILITY STUDY

Leonard Lake, Nez Perce National Forest, Grangeville, Idaho.

A feasibility study was conducted along the Salmon River corridor in central Idaho to test remote sensing imagery as an early detection tool for four noxious weeds. The weeds selected were yellow starthistle, spotted knapweed, leafy spurge and rush skeletonweed. The objective of the study was to detect small isolated occurrences of the four weeds along the rugged canyon corridor of the Salmon River.

Aerial remote sensing data was acquired with a color infrared digital camera at two altitudes: 7,000 feet above ground level and 3,500 feet above ground level. These altitudes resulted in 1 mile and 1/2 mile swath width, respectively. A single flight was conducted to correspond to an optimum flowering period for all four weeds. Five-mile test strips were flown along reaches of known infestations in four geographically distinct areas adjacent to the Frank Church River of No Return Wilderness in central Idaho. These areas were used to field validate the detection of the target weeds. Additional imagery was acquired along relatively inaccessible reaches within the Wilderness.

Image interpretations and field validation were made by forest personnel and assisted by Remote Sensing Specialists from the Remote Sensing Application Center. In general, field validation revealed that the image interpretations were conservative. Large infestations were readily identified, but small low-density infestations were not consistently detected. The lower altitude flight (1/2 mile swath) provided higher resolution, but increased the number of images to process for a given area. Small infestations or low density patches of yellow starthistle and rush skeletonweed were difficult to detect. Leafy spurge, however, was detectable on all the aerial imagery.

Timing of data acquisition is a critical factor in distinguishing noxious weeds from surrounding ground attributes. The window where the target plant's reflective characteristics are most distinct vary by species. In some cases, periods outside peak flowering may yield a more distinctive signature. Varying slopes, aspects, soils and elevations of this particular area made reliable detection of small infestations across a board-scale difficult with this set of data. Growth form of rush skeletonweed and the plasticity of mature yellow starthistle plants compounded the difficulty of early detection.

More reliable results may be achieved with this type of data by focusing on a single species of weed, timing data acquisition to the target plant's unique phenological characteristics, and selecting a more

homogeneous landscape. Color infrared digital imagery may also be a useful and cost effective tool in monitoring broad-scale spread rates of advancing fronts.

BLM Weed Page

National Weed Symposium

April 8-10, 1998

PROCEEDINGS

Address by BLM Director Patrick Shea

April 8, 1998

The weed war is only going to succeed if we reintroduce ourselves to each other.

We have been provided enormous opportunities in the digital age that we can take advantage of, such as long distance learning. However, it is a ready excuse that will undercut the strength of the West, which is higher education. Perhaps we have become so specialized in our respective areas that the traditional relationship between the academy and the field manager is lessened. It is of great importance for the field workers to get their information from universities, but it is a two way street. The universities should get practical information from our managers and incorporate this into the universities. We need to be thinking about how our watersheds can be used as analysis tools. We need to break out of traditional modes of thinking and come up with new ways of addressing the problem. It is rewarding thinking outside the envelope. Examples of this thinking are: the Marriott corporation. They were experiencing problems with their checkout procedure. They chose to study a hospital emergency room check out procedure and increased their productivity significantly. Southwest Airlines wanted to improve the ramp services around the aircraft when they come in. They chose to study an Indianapolis 500 pit crew and increased their productivity. I use these examples to encourage thinking outside the envelope.

With growing pressure on academics to specialize in areas of esoterica in their research, it is easier for them not to network with us. Conversely, with all of the increased demands on a land managers time, it is easy to say "I am not going to get out of this envelope. I am not going to reach to the research scientists because it will take too much time." Don't fall into that mindset.

The Secretary of the Interior has been involved in significant battles on the Hill, and decided to request each of the 11 western states to form Resource Advisory Councils. The idea was to assemble very diverse opinions to get to the issues, and then get their best judgment. Often, the dynamics of bringing opposing points of view into the room brings very workable solutions. We need to think along these lines in battling weeds.

BLM has a very direct interest in fulfilling our FLPMA responsibilities in managing land. If we do not succeed in the weed program, we will have a very significant failure. Everyone knows the enormous negative economic impact weeds have on public lands. My challenge is to find that common agreement on the problem and develop the solution. This conference should be the basis.

Field managers need to think of how to use the science that is available to us. When I talk to field managers about applied science, it was often anecdotal. It was questionable whether what they had done would be replicatable in another location.

I hope in this symposium, you will think of opportunities to share information on your successes and areas of learning.

Along with Mike Dombeck, I will offer a $5000 award incentive to the federal employee who will come up with:

1. the best science proposal and
2. the best on the ground management proposal developed from this meeting.

This award is only available to federal employees as we are not allowed to offer incentive awards to non-employees. Six months from now, a smaller group will reconvene to see what followup has happened as a result of this symposium. Symposiums often create initial excitement and learning, and after time, the information gets shelved. I am hoping that there will be an effort on your part to apply those things you learn today to those areas of your responsibility.

The Secretary of the Interior said that from 1880-1930, the center of science in federal government was the Department of the Interior. When a federal science project was going on, it was under the umbrella of DOI. The Vice President talked about the origins of "good enough for government work." That origin was in the 1920s and meant that it was above the standard of excellence. Over time, that phrase has taken on the opposite meaning, and is often meant as an insult. The Secretary wants to have the Department of the Interior and its sister departments become institutions of high standards of applied science. It is time to sustain an effort to make the field operations side, lab scientists, and local and county governments work together to address this problem.

There needs to be improved understanding of science in wildland weed management at the local level. Carefully identify science needs and allow yourselves to be creative and find solutions. If bound by tradition, creativity won't come. The result of this symposium will be to empower you to involve creative solutions. You will need to spend more time in the field to be able to do this.

Enhanced dialogue between managers and scientists at future dates of interaction will be the key. We will continue to utilize best science, policies of local use, and being a good neighbor. We are entrusted to leave a healthy public land to future generations. This symposium was organized to solve the problems of the explosion of noxious weeds. We will find success when you feel empowered by the ideas that we generate. The success is in your hands.

The weed problem is no longer seen as a one agency problem. It is our collective problem, and we should do what we can together to solve it.

Success is a combination of attitude and timing. We are at a unique time to utilize the partnerships that we create on land management issues. Sometimes, there are folks that want to impose a top down solution. But, I think that the weed problem provides an opportunity for us to grow something that works. Don't look for a solution to come from Washington. You are the ones coming up with the solution, watershed by watershed, county by county, species by species. We are trying to empower our people to work collaboratively with other entities to come up with solutions.

BLM Weed Page

National Weed Symposium

April 8-10, 1998

ABSTRACTS

POPULATION DYNAMICS OF TWO WEED SPECIES FOLLOWING A WILD FIRE

Carolyn Hull Sieg, Ph.D., US Forest Service Rocky Mountain Research Station, Rapid City, SD

In April 1991, a wild fire swept through Wind Cave National Park, in the Black Hills of South Dakota. The fire burned approximately 1100 acres in the Park, ranging from intense "blowouts" in dense ponderosa pine (Pinus ponderosa) stands to low intensity burns in more open pine stands and meadows. Two invasive exotic species, common mullein (Verbascum thapsus) and Canada thistle (Cirsium arvense) became conspicuous components of the post-fire plant community in some areas. In response to park managersþ concerns about the persistence of exotic species in the area burned by the fire, this research project was designed to evaluate the distribution of these two weed species relative to fire severity levels, and quantify the long-term population trends of these species with and without some control measure.

Fire severity was an important variable influencing the post-fire plant community. We sampled post-fire plant composition in lightly burned areas (<10% pine mortality), moderately burned areas (10 to 50% mortality), and in severely burned areas (>90% pine mortality). Although common mullein and Canada thistle were present on lightly and moderately-burned sites, severely burned areas provided areas of mineral soils that these two pioneering species most readily invaded.

In an effort to assess the long-term population trends of common mullein and thistle, we established research plots in dense patches of mullein and dense patches of thistle. Common mullein was by far the dominant species, in terms of cover, frequency, and density, in the mullein plots, in both 1992 and 1993. However, by 1995, common mullein had nearly disappeared from the plots and Canada thistle had become the major species on these sites. On the thistle plots, density of Canada thistle, as well as common mullein increased from 1992 to 1993. By 1995, Canada thistle remained a common species on these plots, but mullein densities were greatly reduced.

Given that mineral soils created by severe fires in dense pine stands provided ideal invasion sites for species such as common mullein and Canada thistle, prescribed burning (and timber harvest, if allowed) is recommended to reduce fuel loads and pine tree densities, and thus decrease the acreage of severely burned stands following wild fires. When wild fires do occur, managers need to use knowledge of the habitat requirements of species of concern in developing post-burn management strategies. Since common mullein is an ephemeral species in this area following burning, efforts to control this species probably are not warranted. Canada thistle is a more persistent species following high intensity fires in

this region, but its population levels are likely influenced by precipitation levels following burning. Additional research is needed to quantify the influence of competition, precipitation, pre-fire population levels, and other environmental factors on the presence and persistence of weedy species following fire.

BLM Weed Page

National Weed Symposium

April 8-10, 1998

ABSTRACTS

A MANAGER'S EXPERIENCE WITH POST-FIRE WEED SPREAD

Bill Baker, Area Manager, BLM Shoshone Resource Area, Shoshone, ID 83352

The two million acre Shoshone Resource Area is located in south-central Idaho, in the center of the Snake River Plain. The Resource Area contains large blocks of degraded, cheatgrass (Bromus tectorum) infested rangeland as well as significant remnants of healthy, native plant communities. The entire Resource Area is subject to high frequency and high intensity wildfire, and is part of one of the largest Federal fire management programs in the nation. In this area, several species of invasive, noxious weeds can establish and expand rapidly following fire.

Over the past 15 years, the Resource Area staff has produced several nationally recognized success stories in coordinated weed and fire management. Of particular note is a leafy spurge (Euphorbia esula) control program in the Raven's Eye Wilderness Study Area. The reasons for success with the coordinated weed/fire program are: dedicated staff, partnerships with external customers, early identification of the first few weeds, a long term commitment to weed management, annual on-the-ground work, good communication and common objectives between "programs", and an aggressive, adaptive management approach to fire rehabilitation.

Nonetheless, following large fires in 1992 and 1996, a rapid invasion of rush skeletonweed (Chondrilla juncea) and diffuse knapweed (Centaurea diffusa) overwhelmed our staff. Although we knew how to address the problem, workload and budget pressures hampered our ability to identify the start of the infestation, inventory the extent, and apply treatments. We believe strongly that the millions of dollars spent on the suppression and rehabilitation of these fires was appropriate. Yet, if we could have invested even five percent of our annual average fire program budget in integrated weed management, then we could have contained, and perhaps even controlled the spread of these two weeds within the fire area. In the 1998 field season, only two years after the last fire, our staff faces a tremendous challenge in containing the now large outbreak of skeletonweed. We can prevent the spread of the weeds to uninfested land. However, applying the best available science to create a successful, integrated weed program will require a major change in budget priorities, a long term commitment to ecological restoration, improved remote sensing technology to detect new infestations, and improvements in both biological and chemical treatments.

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A Manager's Experience with Post-Fire Weed Spread

Bill Baker, Area Manager, BLM Shoshone Resource Area, Shoshone, ID 83352

Abstract: The two million acre Shoshone Resource Area is located in south-central Idaho, in the center of the Snake River Plain. The Resource Area contains large blocks of degraded, cheatgrass (*Bromus tectorum*) infested rangeland as well as significant remnants of healthy, native plant communities. The entire Resource Area is subject to high frequency and high intensity wildfire, and is part of one of the largest Federal fire management programs in the nation. In this area, several species of invasive, noxious weeds can establish and expand rapidly following fire.

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I) INTRODUCTION

This paper describes the Shoshone Resource Area's experience with two weed species that can rapidly invade rangelands following fire. Our work with one species, in one area, has become a heralded success story because we controlled the weed promptly. The other species caught us by surprise and we now face a significant challenge in addressing a large scale infestation. Both case studies present some valuable lessons for dealing with weeds and fire. We also offer some recommendations for the direction of weed research and technological developments that could benefit on-the-ground managers.

The two million acre Shoshone Resource Area is located in south-central Idaho, in the center of the Snake River Plain. The public land administered by the Resource Area is scattered in large blocks across six million acres of predominantly private land, most of which is used for irrigated agriculture. Elevation at the case study sites is approximately 4,100 feet. Average annual precipitation is 8-12 inches, with most coming as winter snow.

Both case study areas can be characterized as degraded, poor to fair condition, cheatgrass dominated rangeland. While we often speak of cheatgrass monocultures, there is actually a fairly diverse plant community in these two areas composed of remnant stands of native bunch grasses, sage brush, annual forbs, a wide variety of seedings, and several fire-philic noxious weeds. The current plant community has evolved over the past 125 years in response to sheep grazing, frequent wild and human caused fire, and BLM management activities including extensive fire rehabilitation efforts. Table 1 shows an abbreviated fire history for the Resource Area.

Table 1 - Shoshone Resource Area Fire Data

YEAR	# of FIRES	ACRES	AVERAGE SIZE	COMMENTS
1955-9	203	234,340	1,154	Start of BLM Fire Records
60-64	244	120,497	494	
65-69	203	79,312	391	
70-74	233	241,054	1,034	
75-79	200	67,587	338	Drought
80-84	285	343,082	1,204	Above Normal Precipitation
85-89	114	44,049	386	Drought
90-94	83	293,279	3,533	Normal Precipitation
95-99	156	342,230	2,194	Three years data

II) LEAFY SPURGE SUCCESS STORY

The Wildhorse Desert, located about 25 miles east of Shoshone, has burned three times since 1981. Immediately following the 1981 Wildhorse Fire (250,000 acres), a BLM Range Technician noticed a few leafy spurge plants sprouting in the burn area. He immediately began spraying, using a boom mounted on an All Terrain Vehicle. The Range Tech also kept a map of every site he came across and sprayed, and returned the following year to respray if necessary, and to note any new patches of spurge.

This individual's concern over a few leafy spurge plants was based on his personal observations of how this plant had spread on nearby private, agricultural land. He did not know if spurge would explode after the disturbance caused by the fire and follow-up fire rehabilitation projects. This was 1981, before Global Positioning and Geographic Information Systems. What the Range Tech did know was that he had a chance to control the weed before the next growing season, especially if he could prevent the few plants from setting seed.

This initial concern and initiative from a single individual was the beginning of a real weed management

success story. It didn't take long for the rest of our operations staff to express an interest in his custom spray boom for an All Terrain Vehicle. Some of the adjacent land owners were watching and began to identify and control leafy spurge on their property. The Wilderness Specialist wanted to know what was going on in the Wilderness Study Areas. Our Range Conservationists began to talk with the sheep permittees and county weed agents. We received calls from universities requesting trials for experimental, bio-control insects. By 1987, we had established an effective, cooperative program aimed at the spurge in this one specific area.

The original Range Tech retired in 1989. His replacement (Uhrig) continued to track and treat the spurge, and tried some new ways of doing business. Working with the Wilderness Specialist, he started using a helicopter and Global Positioning System units. He mapped and plotted the spurge patches using the office's new Geographic Information System. We found that we could effectively locate spurge patches by using the helicopter at the appropriate phenological moment. At the right time of year, spurge contrasts with the surrounding vegetation and is very easy to see from the air. This also turned out to be the best time to spray the spurge, before it had set seed.

Putting it all together, we watched the weather and plant growth indicators, scheduled a helicopter, flew to the spurge patches we had treated in previous years, systematically looked for new patches while we were flying, mapped everything, and treated all the patches before the spurge could set seed. (Please note, we used the helicopter to transport herbicide, we did not aerially apply any herbicide from the helicopter). After several years of experience, we could complete spurge location and treatment in less than two weeks of flying.

We also continued to depend on reports from the sheep permittees, neighboring land owners, and our range staff. Based on our experience, we wrote two programmatic Environmental Assessments in 1992 for weed control inside and outside of Wilderness Study Areas. Environmental groups participated in the NEPA process. While the environmental groups were concerned about the use of herbicides and helicopters in Wilderness Study Areas, they supported the spurge control program because we had proven we could effectively control the spurge. The alternatives were far worse than two weeks of helicopter use every year.

In 1991, we mapped 130 separate patches of spurge in the project area. Last year, after a systematic search of the entire 80,000 acre project area, we found and treated only 30 patches. The project area burned completely as part of large wildfires in 1992 and 1996. We know that spurge can explode following the disturbance caused by wildfire. Yet, due to the annual program that emphasized treatment before seed set, we saw a decrease in the extent and number of spurge plants. It is also important to note that spurge control activities were an integral part of the fire rehabilitation plans for the 1992 and 1996 fires.

The seventeen years of work described above resulted in a real success story. We believed that this accumulated knowledge and technology was applicable to other noxious weeds that can explode following fire. While we had demonstrated success with one weed, in one relatively small area, we were also working on knapweeds, yellow star thistle, dyerswoad, medusahead and other species. We soon learned how one noxious weed, rush skeletonweed, could behave following wildfire.

III) SKELETONWEED CHALLENGE

As part of the Shoshone Office's regular weed management program, we had noticed the gradual spread of rush skeletonweed from west to east across the Resource Area. Beginning in 1994, we treated several small patches. BLM employees, livestock permittees, private land owners and county weed agents all noted the arrival and spread of the new invader. We put an emphasis on one particularly extensive skeletonweed infestation west of Shoshone, and thought that we were making some real progress in skeletonweed control.

In 1995, we found a couple of new patches of skeletonweed in the Wildhorse Desert, about 10 miles away from the spurge project area. This site had burned during the 1992 Black Ridge Fire. We pulled and bagged the plants, sprayed, noted the locations, and worried just a little bit about the vast areas beyond, particularly the Wilderness Study Areas which were seldom visited and so remote. 1996 was a large fire year, including a reburn of a large portion of the 1992 Black Ridge Fire area.

We included what we thought was a prudent and reasonable weed program element in the 1996 Richfield Fire Rehabilitation Plan. Weed control accounted for approximately $40,000 of the $782,000 fire rehabilitation project. We knew that the spurge was out there. We also knew that patches of knapweed and skeletonweed were in the 172,000 acre fire area. However, we believed that the skeletonweed was scattered in only a few small patches which we had already treated.

In the spring of 1997, we saw an explosion of rush skeletonweed and diffuse knapweed in the fire area. These two weeds were even growing in some of the drill seedings (outside of the WSA's) from the 1992 fire rehabilitation project. We had assumed that our state-of-the art seedings were the best way to not only break the cheatgrass fire cycle, but also the best way to effectively provide competition for invading noxious weeds.

As of April 1998, our best estimate is that skeletonweed (and now seed) are spread throughout approximately 100,000 acres of the fire area. It is possible that the 1997 growing season was perfect for skeletonweed and that we will find fewer plants this field season. However, given what we do know about this particular weed, we believe that it has become established across the entire fire area, that a seed bank exists, and that another fire in the next few years could spell disaster. Meanwhile, the skeletonweed patches west of Shoshone have not burned, seem to be stable, and perhaps are even within the realm of control.

Our first priority in the case study area is to prevent skeletonweed from spreading to uninfested areas. We will focus the limited funding and labor available this field season to containing the extent of the population. We will treat the worst of the existing infestation with whatever time and money is left. Large areas will receive no treatment at all. The roadless, rugged nature of the skeletonweed infested area limits our ability not only to detect the weed, but also to apply treatments. The continuous distribution of the plants is also more difficult to address than the scattered, but identifiable small patches of skeletonweed that we had observed earlier.

We think we can contain the skeletonweed infestation to roughly its current area. But even containment will require an annual commitment for many years, and perhaps forever for all practical purposes. Other than the opportunity presented by fire disturbance, we need to determine how skeletonweed is spreading (*i.e.* wind, birds, sheep, rodents, vehicles, or people) and if there are new ways to reduce the rate of spread. The presence of skeletonweed will impact vegetation, grazing and fire management. It will take the cooperation of livestock permittees, hunters, recreationists, and county road crews to prevent the spread of this weed. Fire suppression in this area has obviously been problematic in the past and we will have to reduce fire frequency as well as fire extent. And while we have focused on skeletonweed in the description of this case study, a simultaneous and contiguous knapweed infestation of equal intensity exists in the very same area.

IV) RECOMMENDATIONS AND FUTURE SCIENCE

The following recommendations and research needs are based on the weed and fire management experience of the Shoshone Resource Area staff over the past 15 years. The case studies described above provide a valuable contrast of two dramatically different end results. There are clear lessons to be learned from comparing the two case studies. However, the case studies are only a small part of the overall natural resource management program of a typical BLM field office. Comments and recommendations are certainly welcomed by our staff and should be referred to the Area Manager or one of the contacts listed at the end of the paper.

1) There is no better time to start than now. Noxious weeds that can explode following fire represent a very real, "pay me now, or pay me much more later" scenario. Our experience with leafy spurge and rush skeletonweed population explosions following fire indicates that inventory and control actions need to begin immediately. Because of the foresight of one dedicated employee, a large proportion of the leafy spurge plants never set seed. Great opportunities do exist to promptly control weeds as the first growing season unfolds, before the weed has a chance to set seed. The skeletonweed case study shows what can happen, in only two growing seasons following fire, if the weeds are allowed to establish a seed bank.

Skeletonweed plants and seed are now spread throughout approximately 100,000 acres. While the thirty patches of spurge are spread across a similar 80,000 acre area, the actual spatial extent of the plants and seed is less than 200 total acres. Because we have emphasized treatment before seed set, we believe that the existing spurge seed bank will eventually expend itself. We can confidently predict what amount of helicopter time, labor, and chemical will be required to continue the spurge program on an annual basis.

Over a seventeen year period, we have expended a large amount of time and money on leafy spurge. However, compare our current situation with the spurge to the challenge we face with the skeletonweed. We could easily expend the total time and money from seventeen years of spurge work in one field season of skeletonweed work, and still have only contained the skeletonweed to its current distribution and level of abundance. Controlling the skeletonweed may not be possible in our lifetimes.

In hindsight, if we had systematically surveyed a much larger area (say 50,000 acres) for the presence of skeletonweed in 1995, when we noticed the first few plants, then perhaps we could have programmed skeletonweed work in 1996 as part of the fire rehabilitation plan. We obviously could have spent much more time and money preventing skeletonweed seed set after the 1992 fire, if we had known that a new invasive weed was even in the area of the fire. It is even conceivable that weed seed was brought into the area by fire fighting vehicles from off-District during the actual fire. We test our fire rehabilitation seed for purity, but it is also possible that the rehabilitation projects involving drills and harrows spread existing seed around the project area.

2. Complete planning and NEPA work up front. Much of our weed and fire management successes are a direct result of having weed management direction in our Land Use Plans, having programmatic Resource Area Wide Environmental Assessments for weed control, and including weed management in our Fire Management Plan and Fire Rehabilitation Plans. Planning and the NEPA process allowed us to bring partners into weed management and discuss the science of weed/fire coordination with our publics. We can also move quickly with treatment actions as soon as a new invasive weed is observed on the ground.

The credibility we developed with environmental organizations for the spurge control program in Wilderness Study Areas is an example of a partnership that resulted from the planning process. Our ability to control rush skeletonweed west of Shoshone is an example of how we could move quickly to control an infestation in the same growing season that we discovered the first few plants. Planning and NEPA also help set the stage for cooperative efforts with adjacent private land owners, county weed programs, and adjacent federal land managers. Planning and NEPA are directly linked to the BLM budget process so that treatment programs and integrated, coordinated weed management can be funded more quickly and for the long term.

3. Conduct systematic post fire monitoring and detection surveys. The benefits of only one person looking for leafy spurge immediately after a fire were incredible. Even though the one Range Tech could not possibly find all the spurge patches that we later located with a helicopter, the early start on assessing the magnitude of the problem probably made a huge difference. Having accurate information from monitoring and detection surveys also can help nurture partnerships with permittees, hunters, recreationists, and other agencies.

Once again, remember the exponential population explosion that can happen following fire for some weed species which may already be present. Likewise, this is the only opportunity to catch the first few plants that may establish after a disturbance like fire. If we had caught the first few rush skeletonweed plants following the 1992 fire, we might have had another success story to relate instead of a huge challenge to deal with five years later. If we had performed a more intensive post fire detection survey following the 1996 fire, we would have a much better characterization of the challenge than we are able to present at the time of this paper. Assessing the magnitude of the problem also makes budget justifications more convincing and work planning much more efficient.

4. Improve funding for weed management and research. Weeds will not go away if we only throw more money at them. But, we must at some point examine what BLM spends on weeds, and what it will cost to get the job done in the future. We do not recommend taking money from any existing program. We do not have any suggestions for where additional dollars might come from. We can relate what we have spent on weeds in one typical BLM Resource Area and share our estimates for the Fiscal Year 1999 Preliminary Annual Workplan.

We do wish to emphasize the simple concept of pay less now, or pay much more latter. Table 2 shows estimated costs for what would have been necessary in Fiscal Year 1995 to <u>control</u> the rush skeletonweed described in the case study. The Fiscal Year 1999 column shows what we estimate will be required to <u>contain</u> the skeletonweed. Fiscal Year 1995 was the field season before the 1996 Richfield Fire. Fiscal Year 1999 is the third growing season following the fire.

Table 2 - Estimated Costs for Rush Skeleton Weed Case Study Area

WORK ELEMENT	FY'95 CONTROL	FY'99 CONTAIN
INVENTORY 50,000 ACRES	$50,000	
INVENTORY 500,000 ACRES		$500,000
EDUCATION, PREVENTION	$20,000	$25,000
TREATMENT OPERATIONS AND LABOR	$50,000	$150,000
TOTAL	$120,000	$675,000

In other words, we estimate it will cost almost six times as much to prevent the existing skeletonweed infestation from spreading any further, than it would have cost to control the outbreak in the first place. The amount of our dollar estimates may be questionable and we would certainly like to learn how to accomplish the above work elements for less money. However, the ratio of the total costs would remain the same, even with new and cheaper ways of performing work at our level of the BLM organization. Of course, we did not ask for a $120,000 weed add-on in the 1995 Annual Work Plan. We also doubt that we will receive $675,000 next fiscal year for one weed in one project area.

For comparative purposes only, we wisely spent over $2.4 million on fire suppression and rehabilitation for the 1992 and 1996 fires in the case study areas. Our annual base expenditure for the fire program in South Central Idaho BLM is approximately $1.5 million. Until we get wild fire under control, both fixed annual costs and suppression costs will continue to increase for fire management, irrespective of weeds.

Over the last few years, we spent approximately $25,000 annually on base program weed management for the entire Resource Area. This figure includes labor, equipment, supplies, and funding associated with county cooperative agreements. Table 3 shows a reasonable estimate for annual weed program base costs for the Resource Area, in 1998 dollars. We believe this level of funding would allow us to implement an effective, efficient cooperative and integrated weed management program.

Table 3 - Estimated Annual Weed Program Base Costs

Education, Prevention, Partnerships	$10,000
Inventory	$20,000
Monitoring and Treatment of Known Populations	$75,000
Control of New Infestations	$20,000
Total Annual Base Costs	$125,000

We view these base costs as analogous to the fire program base costs. Just as fire program base costs allow us to respond effectively to emergency wildfire suppression and emergency fire rehabilitation, the above weed program base costs would allow us to respond effectively to emergency weed projects like the two case studies presented in this paper. Once again, for comparative purposes only, we spend more than $125,000 annually on our Recreation/Wilderness Program, Wildlife Program, and Lands Program. We realize that adding these estimated, annual Weed Program base costs to project costs (the skeletonweed project in Table 2 is only one of several separate emergency projects in the Resource Area) for Fiscal Year 1999 would total more than $1 million.

5. Improve remote sensing capabilities. In the leafy spurge case study, we depend on timing the helicopter work so that we can easily spot the contrast between the spurge patches and surrounding vegetation. The contrast is great enough that even small patches of a few plants would show up on a traditional aerial photo. The same principle should apply to satellite mapping of the much larger skeleton weed infestation.

There should be some type of reflection difference between the bare ground, grasses in mid to late summer, and skeletonweed. We used a dollar per acre estimate for completing a skeletonweed inventory this year. If we needed to survey over a half million acres, then remote sensing seems like a viable and cost efficient option. Is the technology available? Could we depend on satellite or aerial observations being conducted on a cloudless day, at the right phenological moment? Other widespread species like knapweed could also be inventoried and mapped in this manner. Remote sensing is particularly appealing on the Snake River Plain because in recently burned areas, there is no sage brush canopy to interfere with imaging.

The most valuable data would be available immediately, without a great deal of processing, so that we could treat areas before seed set. Appropriate inventory timing might also facilitate the use of biological control agents at the most beneficial time of year. The goal should be elimination of as much lag time as possible between inventory and treatment. This objective could be a challenge because for many species like knapweed and skeletonweed, the contrast with surrounding vegetation is greatest late in the growing season, after the plants have flowered.

Finally, before we get carried away with reflectance values, theta band emissions, space based thematic mapping and satellite orbit schedules, it would be wise to remember that remote sensing may not be cost effective for detecting the "first few plants". Improved remote sensing technology would certainly be cost effective, appropriate technology for addressing wide spread existing infestations of noxious weeds. But, the most cost effective method of weed control is likely to remain catching and killing those first few plants before seed set. We will need both remote sensing and good old fashioned field work by people on the ground, including our partners.

6. Base science research needs: So which noxious weeds are helped and hurt by fire? How do different weeds respond to different levels of fire frequency and intensity? There is not a great deal of base research available on specific weed species and fire. This type of research would be very helpful to on-the-ground practitioners, at the Resource Area level. Most of our knowledge has come from years of personal experience, trail and error, and communication with our partners and people with similar problems in other geographic areas. We also benefit from the experience of those to the West of us,

where most of our weeds come from.

Using the leafy spurge case study as an example, we do not really know why the population never exploded following the 1992 and 1996 fires. Was the spurge population dynamic due to our control efforts, climate, soil, competition from other plants, or a combination of factors? Why did the skeletonweed and knapweed populations explode under the same conditions, in the same place? We believe the explosion of these two species occurred due to the major disturbance of two large, severe wildfires in four years, combined with an established seed source. The skeletonweed patches west of Shoshone did not burn and did not explode. Testing this hypothesis could prove beneficial for those East of us, as well as help us design containment oriented treatments. We know that the case study area is going to burn again, the question is when.

We have known for a long time that some weeds will establish and/or explode following fire. However, some weed species can then form self-perpetuating monocultures, some simply become a component of the plant community, while others disappear as a part of normal vegetative succession. If we could predict with some confidence which weed would behave which way, then perhaps we could focus our energies on target species and not worry about the non-persistent, but noxious invaders.

7. Ecosystem Management: Ultimately, large scale ecological restoration is the only way we will ever solve the weed/fire problem in our area. The ecological condition of the two case study areas is the result of over 125 years of human use and plant evolution. It may take more than a century to restore some form of functioning plant community that is resistant to new invasive noxious weeds. What type of integrated weed management effort will be needed to control weeds after future wildfires, while simultaneously promoting biodiversity, native plants, endangered species; producing wildlife and livestock forage, and meeting the human aesthetic and social needs associated with Wilderness?

While biological control is the subject of the next presentation at this Symposium, our staff believes that biological control could offer some assistance is solving fire/weed problems. From the field level perspective, biological control seems like an appropriate technology for the "contain" type of weed infestations, where the weed is beyond our ability to control in the short term. Intuitively, one would think that bio-control agents for a fire-philic weed would at least be fire tolerant, and perhaps even explode in population along with the weed following fire. Is it possible to use bio-control agents to control rapid invaders like skeletonweed so that they become a tolerable component of the plant community instead of a dominant element?

We are working on some of these questions and related ecological studies with the Biological Division of the USGS. We have organized inventory data for weed occurrence, vegetation changes including native shrub loss, land treatments, rangeland improvements and wildfire occurrences. We will soon be able to provide a useable Geographic Information System for both managers and scientists to investigate relationships between current weed occurrences and biotic, abiotic, and land management practices. USGS hopes to predict factors that make locations prone to future weed invasions. We should be able to take a more preventive approach to weed management as well as wildfire rehabilitation in the future using this information.

Certainly interpretation, education, and continuing dialogue with all of our partners will be an important aspect of this holistic approach. We have already seen the results of public education programs. People call our office to complain about knapweed, even though the specific area they are complaining about has less knapweed than it did ten years ago. Weeds were a major emphasis item for the recently completed Scientific Assessments associated with the Interior Columbia Basin Ecosystem Project. Weeds are also one focal point in determining which alternative will be implemented in the Upper Columbia River Basin Environmental Impact Statement. Six of the eight Idaho Standards for Rangeland Health include the statement, "Noxious weeds are not increasing." We need to continually re-emphasize as part of these broad-based, ecosystem efforts that some weeds and fire are closely related, and that weeds need to be addressed as soon as possible, preferably before seed production, and in many cases before the next fire.

V) CONCLUSION

The past fifteen years of coordinated weed and fire management at the Shoshone Resource Area provide several examples of successful weed control, and a few examples of weed containment challenges. A leafy spurge success story showed how immediate treatment, improving technology, and a long term commitment may have resulted in the possible control of this species in the project area despite recurring wildfire. A rush skeletonweed case study from the same general area indicates that this weed can rapidly become established following fire, and then undergo a population explosion with subsequent fire incidents.

While the Resource Area is justifiably proud of our long term successes in fire/weed management and the partnerships we have formed as part of the weed program, we realize that a great deal has yet to be learned about the relationship between noxious weeds and fire. Future scientific research and improved technologies in remote sensing and weed control hold great promise. Yet, weed budget allocations need to be re-evaluated so that we can move forward with the necessary long term ecological restoration of the Snake River Plain.

VI) REFERENCES AND CONTACTS FOR ADDITIONAL INFORMATION

Dr. David A. Koehler, State Weed Coordinator, BLM Idaho State Office, 2620 Kimberly Road, Twin Falls, ID 83301 (208) 736-2363, dkoehler@id.blm.gov.

Steve Popovich, Plant Ecologist, USGS Biological Resources Division, Forest and Rangeland Ecosystem Science Center, 3200 SW Jefferson Way, Corvallis, OR 97331 (541) 758-7761, popovichs@fsl.orst.edu. Current research: Evaluating Emergency Wildfire Rehabilitation Efforts and Monitoring Methodologies of Sagebrush Steppe Ecosystems on BLM Land, Southern Idaho; and Idaho Habitat Change: GIS Formatting of Ecological Data from the Shoshone Resource Area, Bureau of Land Management, Southern Idaho.

Scott Uhrig, Range Technician, BLM Shoshone Resource Area, 400 West "F" Street, POB 2-B, Shoshone, ID 83352, (208) 886-2206, suhrig@id.blm.gov.

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BLM Weed Page

National Weed Symposium

April 8-10, 1998

ABSTRACTS

NEW DIRECTIONS IN CLASSICAL WEED BIOCONTROL

Peter Harris, Agriculture and Agri-Food Research Centre, Lethbridge, AB.

Classical weed biocontrol involves establishing organisms, usually insects, from elsewhere to attack introduced weeds that form dense stands on uncultivated land. The result is often a 99% reduction. The insect must have a narrow host range to minimise direct effects on non-target plants. Presently the world average is the release of 4 species per weed of which 65% are established, but normally control is from a single species. This costs about 20 scientist years per weed species, mostly in host range and establishment studies.

Cut-backs and the change to partial user group funding requires that biocontrol be done faster and cheaper. Changes are also needed to meet public concerns, largely led by ecologists in academia, for native congenerics of the weed which exist for most of our introduced species. There also seems to be a desire to participate in weed biocontrol decisions.

Five suggestions are made for meeting these pressures. 1. Reduce the number of agents used: determine the type of damage to which the weed is most intolerant and use insect species that do this. 2. Improve agent establishment success: choose species with establishment associated with characteristics, such as high voltism, as well as to check that the degree-days of the release area are appropriate for the insect. 3. Reduce the time spent in surveys for agents. The distribution of oligophagous above ground-feeders differs little across the native range of most plants, so surveys can be restricted to the climatic analogue of the release area. In contrast, root-feeders tends to be restricted to the centre of weed origin, so this is the best survey area. 4. Make impact studies reflect the client's objectives. Cattlemen want increased forage, but I see little attempt to measure success in terms meaningful to the client. 5. Change host range studies to meet public concerns. Previously host range limits of candidate agents were determined with larval no-choice tests. Unfortunately the tests tend to indicate that all congenerics are acceptable, even when they are never attacked. A new approach is suggested that determines and quantifies the barriers to utilization of the test plants. The difficulty of adopting new hosts increases with the number of barriers, so I would like to exclude the release of insects with only one. I also feel that opposition to weed biocontrol will be reduced if public input is invited before new weed biocontrol targets are approved.

If appropriate changes are made, weed biocontrol can continue to play a valuable role. If not it is likely to die wither.

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NEW DIRECTIONS IN CLASSICAL WEED BIOCONTROL

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Abstract

Classical weed biocontrol involves establishing natural enemies, usually insects from elsewhere to attack introduced weeds that form dense stands on uncultivated land. The result can be a 99% reduction. The cost for new weeds is about 20 scientists per species, mostly in studies to ensure that the insects do not include desirable plants in their host range, and in the release of ineffective species. Presently an average of 4 species are releases per weed of which 65% establish, but control is normally from one.

Cut-backs and the change to partial user-group funding requires that biocontrol be done faster and cheaper. Changes are also needed to meet public concerns for native congenerics of the weed, which exist for most introduced species in North America. The public also seems to want to participate in weed biocontrol decisions.

Five suggestions are made for meeting these pressures. 1) Reduce the number of agents used: determine the type of damage to which the weed in most intolerant and use species that inflict it. 2) Choose agents with the necessary biological characteristics, such as degrees-day requirements, to thrive in the release area. 3) Reduce the time spent in surveys for agents: for Eurasian species an appropriate area can usually be picked from the literature even though not all of the insects attacking the weed are known. 4) Make impact studies reflect the client's objectives. Cattlemen want forage, but I see little attempt to measure success in these terms. 5) Change host specifity studies to meet public concerns. Previous host range limits of candidate agents were determined with larval no-choice tests. Unfortunately, these tests tend to indicate that all congenerics are acceptable, even those never attacked. A new approach is suggested that determines and quantified the barriers to utilization of the test plants. The difficulty of adopting new hosts increases with the number of barriers, so the safe practice is to exclude those with only one. I also feel that the opposition to weed biocontrol will be reduced if public input is invited before new targets are approved.

If appropriate changes are made, weed biocontrol can continue to play a valuable role. If not it is likely to wither.

Introduction

Classical biocontrol involves establishing natural enemies from another part of the world with the objective of achieving a sustained reduction of a pest to an acceptable threshold. The weeds targeted are typically introduced species that are a problem on uncultivated land, the enemies used are insects and the result can be a 99% reduction. A new weed requires about 20 scientist years per weed species, mostly spent surveying the weed for insects attacking it and determining their host range limits. The complete cost per weed is about $CA9 million dollars.

Weed and insect biocontrol practices were initially identical, but the former has evolved a costly screening process in response to concerns for crops. Recently, the driving forces have changed. In Canada, the funding change from government to user groups with matching government funds means that projects are selected for their interest to a user, so the goals are those of the user, such as increased forage production, and it is difficult to address ecological issues such as species diversity. Commercial users are always impatient for results, so there is a pressure to sacrifice in depth studies for speed and this is aggravated by government reductions of permanent staff. Thus, 20 years to complete a project is not acceptable in either time or cost. The third change is in the plants that are regarded as desirable. Initially, concern was restricted to economic crops, then broadened to include rare natives and finally to all native species and particularly those in the genus of the target weed. This means that the no-choice test is not satisfactory since it does not indicate which, if any, congenerics are at risk which is a problem in North America since most introduced weeds have native congenerics.

Thus, current pressures are to do weed biocontrol faster, cheaper, with new goals and with host specificity tests that reflect the real threat to native congenerics. I have five suggestions for meeting these needs.

1. **Reduce the number of agents used.**

   Early thinking was that the density of a weed reflected the total impact of all the organisms attacking it and that the minimum needed for control is attack of the root, stem, leaves, and flower heads. This was reflected in the projects done in Hawaii and Australia between 1902 and 1928 which intended to release an average of 18 insects species per weed. Their establishment rate was only 22%, partly as disease killed colonies before and after release. The world average is now 4.1 insects released per successfully controlled weed (Myers 1985) with an establishment rate 65% (Julien 1989). Can we reduce the number and increase the establishment rate? I believe the answer is yes because 81% of the successes are attributed to a single organism (Myers 1985) and where two or more are involved, they tend to be effective in different habitats (Harris, submitted) such as *Chrysolina quadrigemina* in summer dry sites and *C. hyperici* in summer moist sites. Disease is no longer a major cause of establishment failure, but more can be done by selecting effective species.

The effectiveness of some species, such as *Rhinocyllus conicus* and *Ch. quadrigemia*, in many countries and climates suggests that they have a special quality. Analysis by Crawley (1983) failed to find it, although establishment success was broadly correlated with high rate of increase, long adult life, high voltism and small size. The alternative is that success is related to the intolerance of the weed to a particular type of damage. For example, leafy spurge is more tolerant of defoliation, whether this is done by mechanically, by sheep, or by herbicides than to damage by the root-feeding beetles in the genus *Aphthona*. With hindsight, I should have measured the ability to regenerate after defoliation (see Meijden et al., 1988), and have saved 6 scientist years by not screening three defoliators. Sowing seed showed that the number had little bearing on the establishment of weed tree *Mimosa pigra* in North Australia (Lonsdale and Abrecht, 1989), but the availability of seed-beds without competing vegetation was vital. Water buffalo were creating the seed-beds and I understand that with their elimination, weed spread has practically ceased. Consequently, I am surprised that 4 of the 8 biocontrol agents released attack flower buds or seeds (Harley *et al.* 1995) and so are unlikely to reduce the existing stands. Stem or root-feeders seem to be more promising and their impact can be investigated by infesting plants in the native region. Root-feeders may be the agent of choice for herbaceous plants that owe their competitiveness to mycorrhizal fungi. Plants that benefit from mycorrhiza use it to augment their mineral and water supply and sometimes to obtain nutrients from the competing vegetation. The interest of root-feeders, such as the knapweed beetle *Sphenoptera jugoslavica,* is that the fungus increases assimilate partitioning to the root (Harris and Clapperton 1997). More examples are needed to determine if this has a broad application as biocontrol is plagued with theories, that are rarely investigated or followed.

In summary, examination to determine whether a plant is most intolerant of root, leaf or seed damage does not take much labour. The payoff is being able to restrict the survey and the screening of agents to a single feeding-guild which should save several scientist years per weed species.

The savings only apply when survey and screening studies are necessary. If the agent can be obtained at little cost because it has been screened by another country, it makes economic sense to try it. In the decade 1981 to 1990, Canada released 6 insects screened by the USA: 2 established and 1 was a success. In the same decade, Canada funded the screening of 19 agent species: 78% established and 33% were successes (Table 1). Although the establishment and success rate of the Canadian species was better than for the US species, the bottom line is that the cost per success of the US species was 0.24 scientist years compared with 6.6 scientist-years for the Canadian species.

The world practice is for one country to screen an agent and all those with the weed, release it. Economically this makes sense, but the safety of the practice depends on the reliability of the test results. I would like to see as a move towards GLP (General Laboratory Practice) standards for screening tests. The standard was developed in

the USA to correct problems in laboratories screening pesticides and medical drugs. In weed biocontrol, the first step of listing basic screening requirements and the requirement for a statement that they were followed, would solve most problems. The list should include: that controls on the host must be run and shown for each test, test insects are disease free, they are from one population or, if several are used, the results are shown separately, and the population is delimited, such as 100 ha in a particular region. This size is clearly arbitrary, but the important thing is that its statement allows the releasing country to decide its acceptability. These practices are not always done and I do not know why the reviewers have not demanded standards. The gain in safety and the assurance that the laboratory records will stand scrutiny by government auditors is well worth the small cost. Also, if government cut-backs continue, commercial laboratories will have to be involved, so GLP standards and auditing will become essential.

2. Avoid species near their range limits.

Currently most agents establish somewhere in North America, but selection of species with Crawley's (1983) establishment characteristics should make it easier. A high rate of increase, high fecundity, multivoltism and small size are also helpful for breeding the large numbers needed for laboratory screening studies, so there is a double benefit.

If the agent is needed to thrive in a particular habitat, biological needs such as degree-day requirements may be important. Canada funded the screening of *Aphthona flava*, which although effective in parts of Montana, has had little impact in Canada, I suspect because its oviposition potential is reduced. I should have suspected that the Canadian prairies were near its distribution limits as its European range extends from the Mediterranean to about 44°N. Native distribution by itself does not disqualify a species, as we have had several that are effective north of their European limits, but it does justify investigation and may be choosing another population or species. Clearly the past practice of releasing better-adapted, but untested populations, is unsafe because they may have different host preferences. *Rh. conicus* is an example. Thus, initial population investigated is important to avoid screening several populations.

I was concerned that a population of *Altica carduorum* from Canada thistle in NW China would not survive on the Canadian prairies. On a degree-day basis its projected distribution only covered about half the area, much of it too dry to have a serious thistle problem. However, in China the beetle appeared to thermoregulate by moving in and out of the sun. When insolation was incorporated in the model, the projected distribution covers most of the thistle infestation (Lactin et al. 1997). Thus, the region is well within the beetle's climatic range, so two scientist years ($900,000) were warranted to screen it.

3. **Reduce the time spent in surveys for natural enemies.**

Australian practice has been to survey for natural enemies throughout the native range of the weed, as done by Harley *et al.* (1955) for *M. pigra*, and by Kovalev (1973) and Wapshere (1974) for *Chondrilla juncea*. This is time consuming, and I think unnecessary. The number of above-ground feeders on *Ch. juncea* changes little across its range whereas the number of root-feeders increase strong towards its Kazakstan centre of origin (Figure 1). I speculate that the root-feeders often have soil texture and moisture requirements so that dispersal involves "island hopping". The decision of where to collect depends on both the available selection and on the climate of the release area. The consequence of releasing a species from a dissimilar climate may be a period of adaptation or establishment failure. With *Ch. quadrigemia* release in Canada the adaptation lasted for up to 10 years.

The situation is more complex for leafy spurge since its fauna has dispersed from a number of refugia. The main spurge problem in North America is along the 49 parallel across the prairies, which roughly coincides with an extension of the southern borders of Germany, Poland and the Czech Republic across Asia. *Aphthona flava*, which appears to have dispersed north from the Mediterranean to just inside this central European region, has failed in Canada. The rich Caucasian assembly of species (Figure 2) was not available for political reason, but the Caucasian species found in Central Europe have all been a success. If we need more agents for special habitats, species in both the Caucasus and Kazakstan are now accessible.

In conclusion, I suggest that survey time can be reduced by restriction to a promising feeding-guild and collection area identified from the literature. I have also found it helpful for getting user group support to explain exactly why I want to collect in a certain region and what I want to find. New organisms found at the same time are a bonus.

4. **Make impact studies reflect the client's objectives.**

I would like to spend more time on the impact and ecological effects of agents, but this is not possible with current restraints. However, studies are often poorly focused, so we could do better with present resources. For example, there have been papers from most US States on the number of *Rh. concicus* per *C. nutans* seed-head. These show that the weevil has become common, but this does not necessarily mean that the weed has declined. If the goal was thistle reduction, the papers are irrelevant, although Rees (1977) stated that seedling numbers decreased in Montana seven years after release, but gave no data. One study, Kok and Surles (1975), that addressed density, showed that stands in Virginia declined by 90-99%. One is left with the impression that there has been no reduction except for Virginia and possibly Montana. I speculate that the number of such papers is a

response to the use of a paper count to measure productivity. If so, biocontrol would benefit from changing the measure.

The real reason for the biocontrol of a weed is rarely reduction of the weed *per se,* but a desire for a different plant association. Cattlemen want forage; nature reserves want diversity of native species and I assume that bureaucrats want to know the monetary payoff. None of these issues have been addressed. It is also important for future projects to know why *C. nutans* stands collapsed since seed reduction at best is only 50% (Harris and Shorthouse 1996). Before biocontrol, about 600/m^2 *C. nutans* seedlings germinated in Saskatchewan stands immediately following the fall rains and self-thinned to about 15 flowering plants/m^2 by the summer (Zwölfer and Harris, 1984). Kok et al. (1986) showed that seedlings do not survive grass competition, so apparently a density of 600 rather than 300/m^2 seedlings is necessary to exclude grass. Thus, other weeds with a similar survival strategy should also be amenable to a seed reducer.

It is impossible to document all the impacts of a successful weed biocontrol project, but at least the clients objectives should be assessed. These are varied. For example, a concern of the Canada Department of National Defence is that leafy spurge decreases the stability of soil to tanks. This is related to reduction in root length per volume of soil following the invasion by spurge, and the improvement can be measured. A private enterprise that ignores the customer does not stay in business and weed biocontrol is no different; but some workers do not seem to realize that the customer has changed from government to user group.

5. **Change host range studies to meet public concerns.**

The means of selecting insect species that will not attack desirable plants has undergone major changes. The Hawaiian 1902 lantana project used judgement without host specificity testing. Australia started host specificity studies in the 1920s by showing that the candidate agent did not survive when confined to desirable plants. However, it was impossible to test them all and the inability to develop on cabbage, for example, only shows that cabbage is not a host. I opted for determining host range limits and tried this with *Altica carduorum* (Harris 1964) and *Ceutorhynchus litura* (1966), but the approach was not favoured by the forerunner of TAG on the grounds that starvation tests on economic plants were necessary for public confidence. However, the objections disappeared after being called the centrifugal-phylogentic test by Wapshere (1974) and being adopted internationally. Use of no-choice tests to determine host range limits work if congeneric plants are of no concern. A review of 20 screening reports showed that only 2 (10%) of the insects did not develop on congenerics in no-choice tests; however, only 2 of those developing on congeneric have attacked North American species in the field. Public concerns are likely to increase, so the no-choice test of congeners is unsatisfactory unless a 90% rejection rate can be accepted.

Anyone with a modicum of entomology knows that the larvae of most insects have such poor mobility that their job is to stay on the host and eat it. This is what they do on congenerics in no-choice tests and on other plants that contain their feeding stimulants. Host selection depends on the female, which is under strong pressure to choose those on which the subsequent stages will do well. It is simply bad science to determine the threat to congenerics on the basis of larval developmental ability in a petrie dish.

We tried a new approach using the Canada thistle leaf-feeding beetle, *A. carduorum* by determining and quantifying the barriers to the utilization of native thistles. In no-choice tests it survived on all *Cirsium* spp., but the product of five performance tests, such as the completion of larval development and egg production, showed that the relative suitability of native thistles in no-choice tests was around a thousand, and in multiple-choice tests, around a millionth of that of *C. arvense*. With these odds, the insect faces population suicide if it cannot reliably distinguish *C. arvense* in the field. Indeed, we found the beetles aggregate on freshly damaged *C. arvense* leaves and to the faeces of beetles fed on it, but not on other thistles. In practice, this means that the beetle does not "see" other thistles.

There is concern that agents will evolve to improve its performance on a marginal host. Andres (1985) suggested that the beetle *Ch. quadrigemina* has done this on the introduced evergreen ornamental *Hypericum calycinum*. The beetle is attracted to it, but faces high mortality because the young larvae have difficulty eating its hard mature foliage, so adaptation could involve the selection of larvae with strong mandibles. In no-choice tests the beetle performed better on native Canadian species of *Hypericum,* but has not attacked them in the field, so reasons for the difference are pertinent. On the target weed, *H. perforatum,* the beetle avoids the effect of photosensitizing chemicals in the plant, which are lethal to larva exposed to sun (Field *et al.* 1989), by breeding on the procumbent foliage in the fall and spring which they hide under during the day. They cannot do this on the native species as they lack winter foliage, and a series of major adaptations would be needed for their summer utilization. Both the introduced ornamental *H. calycinum* and the Californian *H. concinnum* provide foliage at the right time, although neither is an ideal host, the former because of its hard foliage and *H. concinnum* because its foliage is too diffuse. The selective advantage of adapting to these species partly depends on their abundance relative to that of *H. perforatum* and the ratio changed for *H. calycinum* by its use as a ground cover along Californian highways. The use of an agent with several barriers to *H. calycinum* utilization would have avoided the problem.

Unfortunately, the only criterion of host safety presently acceptable to TAG is the inability of a plant to support larval development in a no-choice test. This has had the effect that Canada has ceased supporting the screening of leafy spurge insects since the users see no point screening species that will not be approved. TAG is a group of stake-holder government departments in which all have a veto even though

they have no expertise in entomology. The group has two roles: that of identifying plant species that should not be jeopardized and assessing whether candidate agents will respect the prescribed limits.

I suggest we return to the previous use of separate reports on each issue. The report justifying the biocontrol of a weed species should be reviewed by TAG and then public comment invited, since increasingly they want to participate. Indeed, they have a right to value a weed, such as purple loosestrife, more than a mud turtle it is displacing. A public review ensures that the biocontrol proponents do their homework, as they did for purple loosestrife, it provides an opportunity to educate the public on the issues as well as identification of the plant that should not threatened. The report on whether a given insect is likely to threaten desirable plants is a technical issue and should be assessed by a group with a knowledge of insect behaviour. The present reliance on the larval starvation test is less safe than showing that there is a series of barriers to a host range expansion. A difficulty of getting the necessary changes is that the need for them has to be seen by the regulators.

The need for a new approach for investigating the host range of insects is urgent, but changes cannot be made until there are changes in TAG. Inevitably the tests will increase costs, which increases the need to streamline at other stages.

Conclusions

Arnold Toynbee (1962) in the Study of History suggests that great civilizations, such as the Egyptian, and Greco-Roman, arose as the result of accepting major challenges and declined when they refused new challenges. Weed biocontrol has flourished in the past by addressing its challenges. These have changed, partly from a changed political agenda and partly from an increased public valuation of things native. I have made five suggestions for meeting the challenges, or we can sit on our laurels and wither. Some of the changes are within the researcher's mandate, but I am more pessimistic about getting the necessary regulatory changes made by APHIS because two organizations are involved. Without the regulatory changes, increasing biocontrol efficiency matters little. Thus, the short term prospects are for a gradual withering of support for biocontrol as has happened in Canada for the leafy spurge program

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Figure 1. Distribution of *Chondrilla* spp. and its oligophagus insects

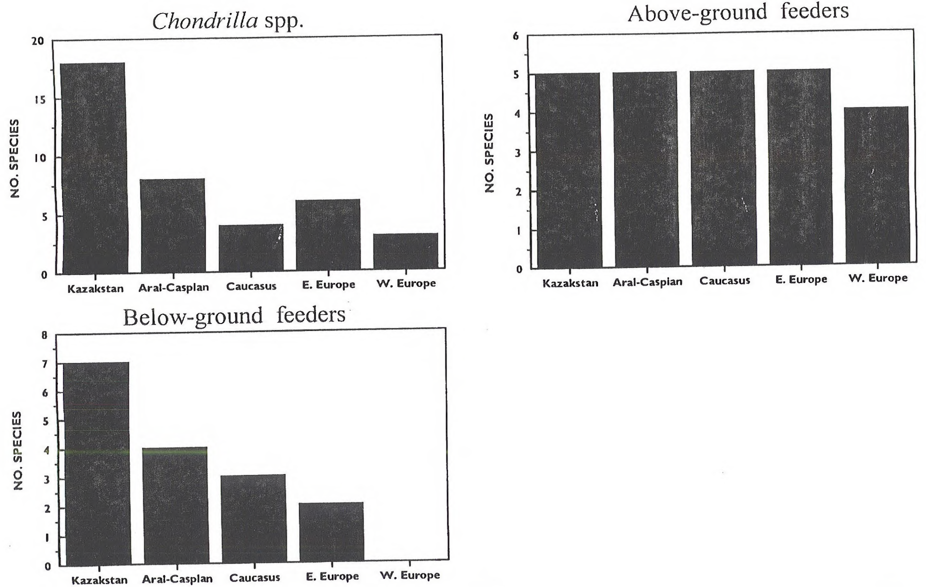

Figure 2. Distribution of northern Paleoarctic *Aphthona* spp. on spurges in the subgenus *Esula*

Aphthona sp.	S. Europe north to Circa 50°N	Germany Poland Czech Rep.	Caucasus	W. Siberia Kazakstan	E. Siberia Mongolia N. China
A. cyanella Redt.	x				
A. flava Guilleb.	x				
A. illigeri Bedel	x				
A. ovata Fourdr.	x				
A. aeneomicans All.		x	x		
A. lacertosa Rosh.		x	x		
A. pygmaea Kutsch.		x	x		
A. venustula Kutsch.		x	x		
A. violaceae Koch.		x	x		
A. abdominalis Duft.		x	x	x	x
A. cyparissiae (Koch)		x	x	x	
A. czwalinae Weise		x	x	x	x
A. nigriscutis Foudr.		x	x	x	
A. reitteri All.			x		
A. sarmatica Oglobl.			x		
A. testaceicornis Weise			x		
A. beckeri Jacobs.			x	x	
A. flaviceps All.			x	x	
A. gracilis Fald.			x	x	x
A. rugipennis Oglobl.			x	x	
A. jacobsoni Oglobl.				x	
A. jacuta Oglobl.				x	
A sajactica Obłobl.				x	
A. tolli Oglobl.				x	x
A. chinchihi Chen					x
A. seriata Chen					x

Table 1. Success of weed biocontrol agents in Canada 1981-1990

Funder of pre-release studies	Canada.	USA.
Canadian costs	2 SY/ agent	0.04 SY/ agent
No. Established	14 (78%)	2 (33%)
Species contributing to control	8 (33%)	1 (17%)
Canadian costs per successful agent	6.6 SY	0.24 SY

* SY = a scientist year, currently about $450,000

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BLM Weed Page

National Weed Symposium

April 8-10, 1998

ABSTRACTS

A MANAGER'S EXPERIENCES WITH BIOCONTROL PROJECTS

Debra Eberts, Bureau of Reclamation, Denver, CO

The Bureau of Reclamation constructs and manages water storage and delivery systems in the seventeen Western states. Dense growth of either aquatic or terrestrial weeds can impede the operation of Reclamation water systems and rights-of-way. Department of Interior policy emphasizes the use of Integrated Pest Management (IPM) techniques to control these weeds.

In helping our field managers implement biocontrol projects as part of their overall IPM plans, we have found that several areas need special consideration. The choice of insect(s), determining if field conditions are suitable for the insect, and the availability of insects can lead to widely different courses of action, as was the case in two Reclamation projects involving purple loosestrife and leafy spurge.

Our biocontrol projects have shown varying degrees of success. We have found that a monitoring program helps managers gather information for future decisions, and increases the rate of success. Projects are monitored for the degree of insect establishment, degree of weed control, effects on non-target species, and the establishment of desirable vegetation.

Overall success of projects has hinged on finding a knowledgeable contact person to help obtain information and insects. Managers need to be prepared to take an active role in the project and allot sufficient time to see results.

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<u>A Manager's Experiences with Biocontrol Projects</u>

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The Bureau of Reclamation constructs and manages water storage and delivery systems in the seventeen Western states. Dense growth of either aquatic or terrestrial weeds can impede the operation of Reclamation water systems and rights-of-way. Department of Interior policy emphasizes the use of Integrated Pest Management (IPM) techniques to control these weeds. **I serve as a technical resource for our weed managers, especially regarding biocontrol. What I'd like to do today is share some topics I discuss with managers when we set up a project, and some problems and results we've seen in some Reclamation projects involving purple loosestrife and leafy spurge.**

This slide illustrates a manager's perspective on biocontrol that I try to discourage. We often tout biocontrol as a "silver bullet" and the manager thinks he can just dump a bag of insects into the field and spend the rest of the summer sitting in an air-conditioned office. These are usually the same managers who will then say, **"I've tried biocontrol, it doesn't work."** A successful biocontrol project needs **planning, regular monitoring, and time**. (I will assume you've already decided biocontrol is the best management option based on the size of the weed infestation, the sensitivity of the site, and the level of control needed.)

The most important step in planning a biocontrol project is consulting with an **expert** in the biocontrol insects for your problem weed. Talk with a researcher from a university or the USDA, or attend workshops or field days. There are also reference books such as *Biological Control of Weeds in the West* by the Western Society of Weed Science and speciality newsletters such as *Leafy Spurge News* out of North Dakota State University. The information from these sources can save you much time and trouble, not to mention money.

As part of planning ahead, I'd like to mention **paperwork**. It is wise to line up a source for the insects a season ahead of the project, and if the source is out-of-state you will need to submit an application to import them. This form is PPQ Form 526, and is submitted to your state's Department of Agriculture, who then forward it to USDA/APHIS/PPQ for approval. This process can take some time. I frequently get requests in April or May to start projects that season, and it is usually not possible to get things together quickly enough.

In helping our field managers implement biocontrol projects as part of their overall IPM plans, we have found that several areas need special consideration. The part of the plant targeted by the insect(s), field conditions, and the availability of insects must all be considered when you choose which insect(s) to use.

Purple loosestrife biocontrol is effective because insects attacking the leaves, roots, and seeds are all available. Sometimes the only biocontrols available do not effectively control the plant on their own, for example, insects may attack seed production but not enough to eliminate all seed. If this is the only insect you choose to use, you may not get good enough control for your investment. Since many of these insects are purchased, you should choose one **targeting a plant feature that will give the best control.**

Choosing an insect that will thrive in the **environmental conditions** at your field site is important. They need to do well, and build up a large population to effect control. For example, many types of flea beetles are available for leafy spurge control, but they each prefer a different habitat. If you try to put one which prefers hot sandy slopes into a forested, shady area, it will not work. Another example is weevils which live in purple loosestrife roots - a constantly flooded site will not allow the insect

population to build quickly to controlling levels. Sometimes it is not so much the site, but how you manage it. At one of my local sites at a Federal Prison, mowing operations were conducted right up to the water's edge. Leaf beetles I had introduced to control purple loosestrife had no good litter cover to overwinter, and there was much mortality. The insects could not increase to control levels from only a few survivors. When the manager changed mowing practices and left a 10-foot border unmowed for the last two mowings of the year, we finally saw better overwintering survival.

Availability of insects is a frequent bottleneck to a new project. Some insects, like leafy spurge flea beetles are available in large numbers and easily collected. Other insects, such as those for purple loosestrife control, must be purchased or reared yourself. Due to large demand for loosestrife biocontrols at Reclamation, I mass-produce the leaf-feeding beetles in Denver and ship them to release sites. Root weevils are much slower to produce and we are working on methods to overcome this so that we may release adults into the field. Currently, we harvest eggs in the laboratory and placed them on plants at field sites (a very time-consuming process).

Once you have the insects, it's important to **release** them correctly. Often they need to be caged so they don't fly away immediately, but can find each other to mate and lay some eggs at your site. Release methods we've used have evolved over time: from large 12' structures, to simple sleeves for individual plants, to open releases. Relying on the experts for advice on this step is important.

Monitoring of your results is important. It doesn't need to be as involved as GIS/GPS mapping, it can be as simple as measuring the diameter of a circle of affected plants, or taking yearly photographs of a permanent site. We try to include some measurement of both plant and insect vigor, but limit the data to motivate managers to participate.

At another of my local loosestrife sites, I have been releasing leaf-feeders since **1994**. **In 1996, I started to see effects on flower spike production**. Last summer I saw dramatic results: plants only about a foot tall instead of 6 feet, and no flowers at all. I tried to show this to as many cooperators as I could, so that they would see that biocontrol would work, given time. This was a small site and it took two or three years to see any effect at all. One of my sites in Washington state is much larger and will require time, patience, and many, many insects.

The Bureau of Reclamation constructed the **Grand Coulee Dam** on the Columbia River in Washington. This project resulted in the formation of two major wasteways which spread water out over the desert in the center of the state. In this same area, a university was conducting apiary studies in the early 1970s using purple loosestrife. There was less than 10 years for desirable aquatic vegetation to become established before the introduction of purple loosestrife. With no real competition, the loosestrife virtually exploded and is now a near-monoculture over **25,000 acres** of desert wetlands.

The manager at the site has taken real pleasure in releasing insects at the **"epicenter"** where the original test plots of loosestrife were planted. This is a very long-term project but biocontrol is the only feasible option for this size infestation. My main concern for this site should be considered for all project sites: revegetation. **The history of the site leaves little seed bank to revegetation, and the size of the site makes the job daunting. Revegetation** will be important or other weeds will move in as we control loosestrife. One plant which <u>is</u> in these wetlands is ***Phragmites***, itself an aggressive weed.

In closing, I would like to say it has been my experience that biocontrol is not a "silver bullet" solution. It requires planning, monitoring, and patience but is certainly a goal that can be achieved.

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ABSTRACTS

RESTORING SUSCEPTIBLE LANDS AND POST-WEED CONTROL RESTORATION

Roger L. Sheley

Sustainable weed management will require that land managers develop methods to design and establish desired plant species that provide healthy, relatively weed-resistant plant communities. Healthy, weed-resistant plant communities are those which maximize niche occupation by optimizing diversity. Revegetation can be used to prevent weed encroachment into uninfested areas and to rehabilitate or restore desired plant communities in weed infested areas. On lands under the threat of invasion, species which occupy similar niches as the invading weed can be established with the aim of reducing niches, and therefore, establishment of the weed. On areas with large infestations, sites with high-quality soil may be either rehabilitated or restored. However, this important weed management technique is rarely used because of the high cost and probability of failure. Successful revegetation will require decision support tools to help managers identify those where revegetation is necessary. Because establishment from seeds is so difficult and costly, it is imperative that we are able to identify those sites with enough residual native species to respond to weed control and prioritize control activities to preserve those species. On areas without residual desirable species, reestablishing desired species is critical to long-term and cost-effective weed management. Future research must focus on development cost-effective and reliable revegetation techniques and systems. Current establishment strategies have been based on farming practices, and require three to five input entries onto the site. Our goal is to develop a one pass revegetation program for accessible land infested with weeds, and to develop "island" seeding methods for inaccessible rangeland. Finally, it is important to focus on developing principles and concepts on which management should be based, rather than site specific prescriptions. We believe that successional weed management should be used to guide the implementation of revegetation and integrated weed management strategies.

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REHABILITATION OF WEED-INFESTED RANGELAND

James S. Jacobs, Michael F. Carpinelli, and Roger L. Sheley

Introduction

Current weed management efforts often focus on simply controlling weeds, with limited regard to the existing or resulting plant community. Because of environmental, ecological, and economic concerns, the appropriateness and effectiveness of rangeland weed management practices are being questioned. It has become clear that weed management decisions must consider these concerns. The development of future weed management practices must be based on our understanding of the biology and ecology or rangeland ecosystems.

Land use objectives must be developed before rangeland weed management plans can be designed. This implies that strictly killing weeds is an inadequate objective, especially for large-scale infestations. However, a generalized objective could be to develop a healthy plant community that is relatively weed-resistant, while meeting other land-use objectives, such as forage production, wildlife habitat development, or recreational land maintenance.

Highly degraded rangeland dominated by noxious weed is often devoid of competitive desirable plants. On these sites, rangeland weed control is often short-term because desirable species are not available to occupy niches opened by weed control procedures (James 1992, Sheley et al. 1996). Introducing and establishing competitive plants is essential for successful management of weed infestations and the restoration of desirable plant communities (Hubbard 1975, Larson and McInnis 1989, Borman et al. 1991). However, revegetation is often not included in a weed management plan because it is costly and there is a high risk of failure. The process of revegetation must first identify the desirable plant community that meets management objectives and then determine the seeding method, herbicide treatment, species to be seeded, and follow-up treatments to best achieve the desirable plant community.

The decision to revegetate must consider direct costs (seedbed preparation, seeds and seeding, follow-up management), indirect costs (risk of failure, non-use during establishment period), and benefits (increased forage, improved ecosystem function, soil conservation). Revegetation efforts should focus on sites and methods with the greatest potential for increasing net benefits in the shortest amount of time.

Rangeland revegetation is costly because current methods use agronomic practices. Typically, revegetation of weed-infested rangeland requires multiple entries. First, the site is disced in late-fall to loosen the soil surface and encourage the germination of weed seeds present

in the seedbank. A few weeks later, a non-selective herbicide, such as glyphosate (N-[phosphonomethyl] glycine) is applied to kill the newly establishing weeds. The combination of discing and herbicide application reduces the number of weed seeds in the seedbank and reduces weed competition in the following spring. Soon after the herbicide is applied, fall-dormant grasses are seeded. The following spring, some of the remaining weed seeds in the seedbank and seeded grasses germinate and emerge. With adequate spring precipitation, both grass and weed seedlings survive. If grass seedlings survive until mid-summer, a reduced rate of 2,4-D ([2,4-dichlorophenoxy]acetic acid) or mowing is usually applied to weaken weeds and retard them from going to seed. Although revegetation with aggressive species has been shown to inhibit weed reinvasion (Borman et al. 1991, Hubbard 1975, Larson and McInnis 1989, Huston et al. 1984), managers are reluctant to attempt it because of the high probability of failure and expense associated with this multiple-entry approach. Effective, single-entry methods must be developed for revegetation to be affordable and applicable to remote areas.

Failures in revegetation of weed-infested rangeland are usually caused by the combination of a number of factors. The most important are insufficient soil moisture and intense weed competition. While some factors, such as climate, are beyond our control, we can use what we know about ecology to improve our success rate.

Seedling establishment is the most critical phase of revegetation (James 1992). Seedling establishment appears associated with the availability of safe sites (Harper et al. 1965, Wright et al. 1978) and the availability of seeds (Pickett et al. 1987). Rehabilitating weed-infested rangeland with desirable grasses typically fails, however, because of competition with weeds for safe sites during the initial stages of establishment (Borman et al. 1991, James 1992). In addition, density-dependent (e.g., competition) and density-independent factors (e.g., climate) interact to determine seedling survival during grass establishment in weed-infested rangeland (Velagala et al. 1997). Revegetation methods must address both of these factors to improve revegetation success.

Seeding Methods

Seedbed preparation and seeding depth are factors that affect seedling survival. The ideal seedbed for range seeding consists of pulverized surface soil with moderate amounts of mulch or plant residue, firm soil below seeding depth, and no residual competitive plants. Ideal seeding depths are about one-quarter inch for small seeds, and one-half inch for large seeds. Site conditions and cost will determine which seedbed preparation method is most appropriate.

Plowing and drilling. Plowing is the most effective method for preparing an ideal seedbed. However, it is costly and only practical on sites that are accessible to machinery and which have fertile, deep, and rock-free soils. Plowing not only removes competitive vegetation, it increases the establishment of seeded species. Seed placement is enhanced by plowing because the roughening of the soil surface increases the number of safe sites. Plowing also loosens the upper layer of soil, thus facilitating root extension by establishing seedlings. In areas that can be farmed and intensively managed, plowing and drill-seeding has the best chance of insuring revegetation

success. A typical three-year intensive revegetation plan includes plowing and seeding an annual hay crop in the first and second years, and replowing and seeding to a grass-legume mixture in the third year. The hay-cropping allows for the germination and removal of weeds from the seedbank while providing immediate financial return.

No-till-drill. The no-till-drill is a tractor pulled machine which opens a furrow in untilled ground, drops seeds in the furrow at a specified rate and depth, and then rolls the furrow closed. This method is the most practical and commonly used method on rangeland that is accessible to machinery because it is less expensive than tillage and because it reduces the risk of erosion associated with tillage. This is especially important in arid and semi-arid areas where tillage may exacerbate wind and water erosion. Because this method does not remove competitive plants, no-till-drill seeding is commonly preceded by a non-selective herbicide application.

Broadcast seeding. On sites that are inaccessible to machinery, site preparation is limited to removal of competitive plants via herbicide or fire. On small-scale projects, seeds are typically broadcast with a hand-held seed scattering device. Large-scale projects are usually helicopter seeded. Untilled soil is usually lacking in safe sites, which may be countered by using a higher seeding rate than would be used on plowed ground. Covering seeds with soil or mulch improves germination and establishment. Other disadvantages to broadcast seeding are poor seed distribution, loss of seeds to rodents and birds, and slower establishment.

Alternative methods. Recent studies show that increasing the seeding rate above agronomic levels improves grass seedling establishment on weed-infested rangeland (Jacobs et al. 1996, Velagala et al. 1997, Sheley et al. Manuscript). Alternative revegetation methods may be developed that use high seeding rates without increasing cost. For example, a strip-tilling/seeding method could seed desirable species at high densities on evenly spaced tilled strips. Successful seedling establishment would be increased because of the high seeding rate, and under proper management, the established species within the strips would spread naturally to the interstrip area. One way to facilitate the expansion of seeded species to the interstrips would be to first apply herbicide to remove existing vegetation from the entire area prior to strip-tilling/seeding. Another way would be to use selective grazing of broadleaf species by sheep or goats to control the establishment of weeds in the interstrips. Similarly, islands of desirable plants could be established using high seeding densities so that the plant cover is dominated by desirable species. From these islands, desired species could spread naturally.

Herbicides

Herbicides provide an alternative to tillage for the removal of unwanted vegetation. Herbicides are often used where accessability or erosion is a concern or tillage is cost-prohibitive. Herbicide selectivity, persistence, and timing of application are important considerations when deciding how to use herbicides for weed control in revegetation.

Non-selective herbicides. Most revegetation seedings are preceded by an application of a non-selective herbicide such as glyphosate. On rangeland where fall-dormant seedings are most practical, a late-season application of glyphosate can be used to eliminate fall-germinating annual weeds like cheatgrass and yellow starthistle that have emerged prior to the application. This may substantially reduce weed competition for early season moisture during the following spring.

Broadleaf herbicides. Broadleaf herbicides are often used in rangeland revegetation because most weeds are broadleaved species and most seeded species are grasses. An advantage to some broadleaf herbicides is they have soil residual that will control broadleaf seedlings for up to 18 months. Picloram (4-amino-3,5,6trichloropicolinic acid) applied at a rate of 0.28 kg a.i./ha provides control of many weeds for 2 or 3 years (Davis 1990). The combination of glyphosate and a residual broadleaf herbicide, such as picloram, may provide the best control of weeds for a one-pass revegetation procedure where only grasses are seeded. Broadleaved desirable species can be incorporated once the grasses are established and the residual effect of the herbicide is gone. Of course, where broadleaved desirable species are seeded in a one-pass operation, herbicide selection will be limited to a non-residual broadleaf herbicide such as 2-4, D or a non-selective, non-residual herbicide such as glyphosate.

Species Selection

Selection of species is determined by intended use, soils, precipitation, temperature, and establishment characteristics of the desired species. Another important consideration is the ability of the desired species to withstand reinvasion. For example, many aggressive introduced species and some native species have been shown to reduce leafy spurge infestations.

Intended use. The intended use of a revegetation site is important in determining what species to plant. If livestock grazing is the intended use, a perennial with high forage production is an obvious choice. One such species, crested wheatgrass, is a good spring pasture bunchgrass that can withstand a 60% defoliation without affecting its biomass production (Sheley and Larson 1997). Intermediate wheatgrass, a late-maturing grass, may be more appropriate if the intended use is summer pasture. Some areas such as state and federal parks, mandate the use of native plants. Here, the plant community composition prior to weed invasion should be used as a guide to determine which species to seed.

Soils. Soil texture affects the establishment success of seeded species. While medium- to fine-textured soils are optimal for most species, some species do best in either sandy or clayey soil. For example, Indian ricegrass and pubescent wheatgrass are well adapted to sandy soils, western wheatgrass does well on clayey soils, and most other species commonly used in revegetation do well on medium- to fine-textured soils (Table 2).

Precipitation. Seeded species need to be adapted to the precipitation level of the site. Crested wheatgrass and Russian wildrye (introduced species), and Indian ricegrass and bluebunch wheatgrass (native species), are adapted to rangeland sites receiving 10-12 inches of annual

precipitation. Pubescent wheatgrass and intermediate wheatgrass (introduced species), and green needlegrass and western wheatgrass (native species), are adapted to 13-15 inches of annual precipitation. Requirements for some other common revegetation species are summarized in Table 1.

Temperature. Temperature zones should be considered when designing seed mixes for revegetation. Warm season, C4 grasses (e.g., big and little bluestem) are well adapted to the midwestern prairie. Cool season, C3 grasses (e.g., Idaho fescue and bluebunch wheatgrass) are well adapted to mountain meadows of the Great Basin. Seed supply companies are good sources of information on the environmental requirements of revegetation species.

Establishment. Species differ in how fast and how well they establish. Crested and pubescent wheatgrasses are some of the easiest species to establish. Natives are generally slower and more difficult to establish. Seed size presents a trade-off between quick establishment and seed placement. Generally, larger seeds establish quickly, but do best if drill seeded or sown in tilled ground. Smaller seeds are more likely to find a safe site in untilled ground, but their limited amount of stored carbohydrates may inhibit establishment.

Designing seed mixes. Though grasses dominate rangeland and are the most commonly used species in revegetation, it is advantageous to use a combination of growth forms when designing seed mixes. For example, seed mixtures of grasses with legumes improve the rate soil recovery on CPR land. In addition, a species mix of contrasting root growth forms (e.g., fibrous-rooted grasses and taprooted forbs) is more likely to maximize niche occupation and resource use (Jacobs and Sheley 1999). In turn, where resource use is maximized, productivity is maximized. A diverse plant community is likely to be weed-resistant because few resources are available to a potential invader. Niche occupation can also be maximized on a temporal scale by combining species that grow at different times of the year.

Seeding Rate

Increasing seeding rate can be used to alter the competitive interaction between desired species and weeds and aid stand establishment. Increasing densities of intermediate wheatgrass from less than 1000 seeds/m^2 to over 1000 seeds/m^2 removed the effect of spotted knapweed on intermediate wheatgrass where interspecific interference occurred (Velagala et al. 1997). In a field study, Velagala (1996) found the greatest seedling establishment at the highest seeding rates, especially when combined with tillage. In that study, intermediate wheatgrass establishment did not occur at a seeding rate of 500/m^2, which is the standard recommended seeding rate. The wide range of seeding rates studied by Velagala (1996) showed the potential for using seeding rate to enhance establishment.

Seed Treatments

Seed treatments may enhance the establishment phase of revegetation. Seed priming (Callan et al. 1990) is a treatment that initiates the germination process in a seed, allows it to continue to a certain point, and then suspends it. The primed seed is then ready to continue germination in the field when conditions are favorable. The idea behind seed priming is that the first seedling to capture resources has a competitive advantage (Harper 1980). Another advantage to priming is that dormancy is broken and germination is assured. This treatment has been shown to aid establishment under agricultural conditions, and it holds promise in rangeland revegetation.

Soil pathogens may accelerate the death of seeds and seedlings. Their role is best understood in crop species, though Tadros (1957) found fungal decomposition of seeds or very young seedlings in the soil could account, in part, for the different floristic composition of the natural vegetation on serpentine and non-serpentine soils. Seed fungicide treatments confer numerous advantages, including protection against diseases and pests and enhancement of growth (Powell and Mathrews 1988). A variety of these methods are commercially available for grass seeds and are intended to improve seedling establishment in reclamation projects (Taylor and Harmon 1990). Perennial grass seeds and seedlings can be protected from soil-borne organisms, including *Pythium* and *Rhizoctonia* spp., and many of the systemic fungicides provide the crowns and roots with a longer protection against *Fusarium* spp. and common root rots (Sprague 1950).

Putting It All Together

For revegetation of weed-infested rangeland to become more widely applicable to the various rangeland conditions, cost-effective and reliable methods need to be developed. Developing strategies that enhance our ability to cost-effectively establish desired plant communities may provide ranchers and land managers with a sustainable method for managing noxious weed-infested rangeland. Reducing the number of entries onto the land will reduce the cost of revegetation. Combining the factors discussed above to improve the success of establishing desirable species, and applying them in a single pass will be the most cost-effective and reliable way to revegetate rangeland. New equipment has made possible the simultaneous application of herbicides, tillage, and seeding as well as seeding using no-till methods.

Revegetation will be most successful if it works with successional processes. The three processes that influence the direction of succession are site availability, species availability, and species performance (Sheley et al. 1997). Combining these three processes in a revegetation application will provide the highest chance for long-term success. Using tilling, herbicides, or intensive grazing are ways to create available safe sites. Species availability is accomplished by successfully selecting and distributing seeds. Herbicides, fertilizers, and selective grazing can be used to desirably affect species performance.

Follow-up Management

Money and effort spent on revegetation will be wasted unless management practices are changed to favor the desirable species that were seeded. Rangelands are dynamic plant communities that are constantly being shaped by the process of succession. Successful revegetation requires that managers continuously monitor the land and adjust management practices so as to direct succession in a way that maintains a desirable plant community. For example, timing and frequency of cattle grazing can be adjusted to minimize the impact on grasses. Sheep or goats can be used to target broadleaved weed species. Biological control can be used to reduce the performance and seed production of weeds. Livestock given feed containing seeds of desirable species can be used as a tool to ensure species availability. The possibilities are endless, and the success is dependent on the creativity and vigilance of the land manager.

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BLM Weed Page

National Weed Symposium

April 8-10, 1998

ABSTRACTS

RESTORATION WITH NATIVE PLANTS

Larry K. Holzworth, USDA, Natural Resources Conservation Service, Bozeman, MT

The invasion of noxious weeds into rangeland, cropland, forestland, urban areas and transportation and utility corridors continues to increase. Weeds impact our natural resources by reducing agricultural commodity production, competing with native species diversity and ecological systems, decreasing wildlife habitat, and impairing recreation areas natural aesthetics. Even with strict state laws mandating noxious weed controls and years of herbicide application, the weeds continue to spread. Water quality, environmental pollution, reduced agricultural production, native plant diversity, etc., will restrict herbicide application in the future. Currently, many chemicals are at risk of being removed from EPA registration. Alternative weed suppression techniques and strategies must be researched and utilized in the future. Crop rotations on cropland, use of certified "noxious weed free" seed, turf, straw, hay, soils along with biological and cultural and management controls in urban and agricultural areas will become our best defense against noxious weeds for the long term.

The Natural Resources Conservation Service (NRCS) is using a combination of strategies to address noxious weed suppression on private lands:

- Coordinated Resource Management (CRM)
- Vegetation Management
- Natural Resource Conservation Planning
- Cooperative Studies

Coordinated Resource Management (CRM), the cooperation among private and public land managers, is being practiced in Wyoming to attack noxious weed invasion. The Bump Sullivan/Springer CRM near Torrington, Wyoming has successfully attacked the spread of noxious weeds. NRCS, Goshen County Weed & Pest Control District, South Goshen County Conservation District, the Springer Wyoming Fish and Game Unit, private industry and private land managers worked together to manage the problem weeds.

NRCS is currently assisting landowners develop plans to seed highly erodible cropland to perennial vegetation. Revegetation with desirable and adapted native or introduced species immediately following a disturbance lowers the risk of noxious weed occupation. Weeds are opportunistic and will occupy sites that are disturbed by land abuse or use. Revegetation involves a few basic principles:

1. Removal or suppression of competition by seedbed preparation
2. Selection of adapted species
3. Proper seed placement
4. Protection of seedlings through establishment from use and competition

These principles have been practiced on cropland for years and have proven successful.

All the Resource Conservation Management plans developed in cooperation with private landowners encourage them to abide by the state and county noxious weed laws, specifically "it is unlawful for any person to permit any noxious weed to propagate or go to seed on his land." In addition, Certified seed is recommended for all vegetative practices to eliminate the importation of contaminated seed. Landowners are informed of the State seed laws and advised to be aware of improperly labeled seed lots.

Revegetation studies on timber harvest sites in western Montana have been conducted since 1993 and are providing similar results. The objectives of the studies were:

- to minimize soil erosion and water pollution,
- provide for a short-term forage resource,
- suppress noxious weed invasion,
- and to determine herbaceous revegetation impacts on tree regeneration.

The results of the long-term studies show how several native and introduced species can accomplish the objectives without interfering with the re-establishment of timber species.

Weed control is everyone's responsibility. Each individual property owner, agricultural or urban; or individual using our natural areas such as forests, parks and wilderness, has weed control responsibility. Working together in a coordinated effort, weed science will help ensure a healthy environment for all of us to enjoy.

RESTORATION WITH NATIVE PLANTS

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NATURAL RESOURCE CONSERVATION PLANNING

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All the Resource Conservation Management plans developed in cooperation with private landowners encourage them to abide by the state and county noxious weed laws, specifically, "it is unlawful for any person to permit any noxious weed to propagate or go to seed on his land." In addition, certified seed is recommended for all vegetative practices to eliminate the importation of contaminated seed. Landowners are informed of the state and federal seed laws and advised to be aware of improperly labeled seed lots. Management plans are developed for all vegetative practices, i.e. range seeding, pasture and hayland planting, critical area revegetation, etc. If revegetated areas are not properly managed, weeds will invade, impact the long term productivity of the management unit, and waste revegetation costs. Early identification of weed populations and follow-up control is essential.

COOPERATIVE STUDIES

Revegetation studies on timber harvest sites in western Montana have been conducted since 1977 and are providing information on seeding forage grasses following timber harvest. The objectives of the studies are:

- to minimize soil erosion and water pollution,
- provide for a short-term forage resource,
- suppress noxious weed invasion,
- and to determine herbaceous revegetation impacts on tree regeneration.

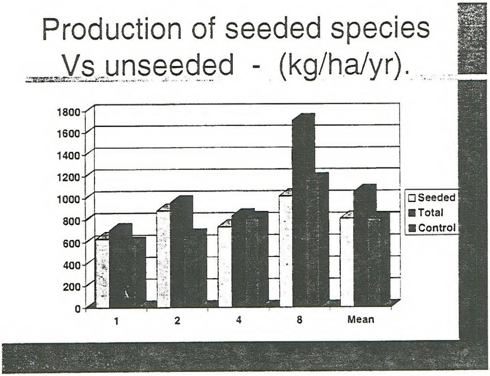
Private timberlands

The first study was started in 1977 in southwest Montana near Dillon. The objective was to evaluate plants for their adaptation and growth on disturbed forest areas such as timber harvest patches and access roads. The site was an Engleman spruce-twinflower Forest Habitat Type. Ten grass and legume species were broadcast planted at a target rate of 40 seeds/ft^2 in non-replicated plots following an 80% surface scarification after timber harvest. Species

composition was measured using line intercept transects and forage production was harvested from three 9.6 ft^2 clipping frames after plant maturity.

The second study began in 1983 in western Montana near Missoula. The study had the same objectives and planting methods as the 1977 study but was conducted on three different Forest Habitat Types: warm-dry Ponderosa pine/Idaho fescue, warm-moist Douglas fir/snowberry, and cool-moist subalpine fir/twinflower. Species entries were selected considering past performance and potential adaptation to respective sites. The plots were monitored for eight years using permanent line intercept transects for species composition and forage production sampling frames as described in the 1977 study.

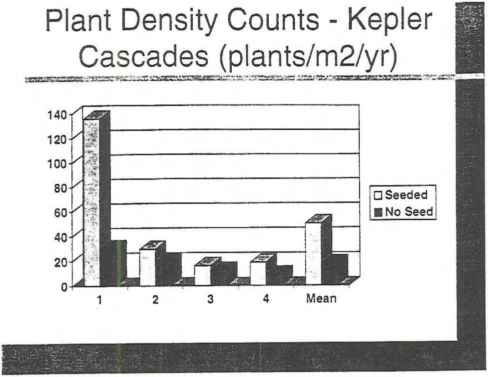
Composite average production comparisons for years one, two, four and eight, across all four sites, shows artificial planting did not increase the total natural cover as compared to the controls. (See graph) However, planting immediately following a disturbance showed that desirable/adapted species reduced the chance of noxious weed invasion. Ocular estimates showed 35% spotted knapweed encroachment into the control and adjacent unseeded plots after ten years on the warm-dry ponderosa pine/Idaho fescue habitat type. The seeding provided excellent erosion control by shifting succession from a forb to a grass composition. The results of these long-term studies also showed how several native and introduced species can accomplish the objectives, without interfering with the re-establishment of timber species.



National Park Service

The National Park Service is taking the "restoration" approach to reestablishing native plant communities, by salvaging topsoil and planting native indigenous plant materials. Since 1985 Yellowstone and Glacier National Parks have been working with the USDA-NRCS Plant Materials Center (PMC) in Bridger, Montana to identify native plant species from which seed can be readily collected, propagated on a large scale, and successfully established on reconstructed roadsides. Early colonizers are utilized for initial invasive weed protection and soil stabilization, but late seral species are added to mixtures to add longevity to resulting plant communities.
Native seed was collected in 1986 and was either seeded directly onto disturbed sites or used to establish seed production fields at the Bridger PMC. Two test sites along the West Thumb to Old Faithful road reconstruction area were established to monitor and document seeded and "seed rain" from adjacent undisturbed plant communities plant establishment and survival. The plots were laid out on cut slopes extending from the road ditch to the forest edge. The plots were seeded by hand broadcast in fall 1988 with a mixture of native indigenous grasses and forbs. Plant density counts and basal cover estimates were made from ten 20 X 40 cm frame samples along a permanent transect from 1989 through 1992.

Results of the monitoring showed seeded plots had higher plant densities than did the nonseeded plots. (See Graph) Seeded species did not compete with native propagules coming in naturally from the adjacent and topsoiled seed sources. As the grasses developed and began to dominate and stabilize the site, the actual number of weedy species were reduced.



COORDINATED RESOURCE MANAGEMENT
Coordinated Resource Management (CRM), the cooperation among private and public land managers, is being practiced in Wyoming to attack noxious weed invasion. Wyoming's CRM Program has been and continues to be extremely successful at resolving conflicts related towards improving their natural resources. Wyoming is the nations leader in training, facilitating, supporting and assisting over 70 active collaborative planning processes. The CRM process, past and present successes, is based on the belief that people with common interests can work together if they 1) communicate and 2) adopt a cooperative attitude.

In Wyoming, there are numerous CRM's that were initiated to address noxious weed management. One of the most successful is the Springer CRM. Originated to control Canadian and musk thistle, and Russian knapweed on the Wyoming Game and Fish Bump Sullivan/Springer Wildlife Habitat Unit near Torrington, Wyoming. NRCS, Goshen County Weed & Pest Control District, South Goshen County Conservation District, the Springer Wyoming Fish and Game Unit, private industry and private land managers, twenty-two organizations in all, worked together to manage the problem weeds and have successfully attacked the spread of noxious weeds.

SUMMARY
The NRCS is using a combination of strategies to address noxious weed suppression on private lands. Technologies are transferred to land owners through natural resource conservation plans. Management plans are developed for all vegetative practices and address noxious weed suppression through maintaining healthy, weed resistant, sustainable and productive plant communities. If revegetated areas are not properly managed, weeds will take the opportunity to invade, which impacts production and wastes revegetation costs. Most of the vegetative management technologies come from local research institutions, land owners and NRCS technical staff experiences and cooperative studies that address current conservation concerns. The cooperative studies have been instrumental in determining the adaptation/performance of plant materials and testing cultural and management strategies. The Bridger PMC has worked with the National Park Service to restore disturbed roadsides to native plant communities. Their research and on-the-ground application has provided valuable insight and knowledge into native plant propagation, culture and management. Wyoming has been very successful using CRM to pull landowners together for noxious weed control. The following list summarizes the lessons of many studies and experiences which have proven effective weed suppression techniques.

REVEGETATION SUMMARY

- Plant Immediately after Disturbance
- Timing is Everything
- Plant Desireable Adapted Species
- Manage Stand for Weed-Resistance/Sustainability
- Maintain Healthy Vigorous Plants
- Little Things Add to Large Differences
- COMPETE & DEPLETE

Additionally, there are future needs that when implemented will assist with noxious weed suppression.

FUTURE STRATEGIES

- Weed Control Is Everyone's Responsibility
- Watershed-wide Coordination is a Must
- Alternative Weed Suppression Techniques Offer the Best Future Management of Noxious Weeds
- Weed Science Research & Education Must be Continued

Weed control is everyone's responsibility. Each individual property owner, agricultural or urban; or individual using our natural areas such as forests, parks and wilderness, has weed control responsibility. Working together in a coordinated effort and using weed science technologies will help ensure a healthy environment for all of us to enjoy.

BLM Weed Page

National Weed Symposium

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ABSTRACTS

ESTABLISHING A SUSTAINABLE VEGETATION ECOSYSTEM TO REPLACE NOXIOUS WEEDS

Tom Whitson, University of Wyoming Extension Weed Specialist

Dealing with the revegetation of disturbed or degraded land is always a challenge that requires a systems approach to be long-lasting and successful. The system of combining a herbicide for weed control with a reseeding program has been tested at the University of Wyoming for 12 years and is providing excellent weed control with only the initial herbicide treatment.

Dealing with weed problems requires a prescription herbicide treatment before establishing a highly competitive perennial grass. Grasses should be cool-season, have moderate desirability for livestock and wildlife and establish well on difficult sites. They should be well adapted to an area and be long-lived. To determine most suitable grasses growers should visit the NRCS Plant Materials Center in their area to look at grasses best adapted for a revegetation site.

Vegetation management requires a different strategy for each weed species that can dominate if managers fail to properly establish perennial vegetation. Three types of weeds are always present no matter where we work. Those are annuals, biennials and perennials. Each species within these groups have to be managed a different way to give the most economical, successful and long-lasting vegetation management system. A herbicide must be applied at the proper stage of growth for the best and most economical control. Annual bromes or annual broadleaved weeds are best controlled before they produce seedheads.

Biennials such as musk thistle work best after all new seedlings have emerged but prior to the controls for two-year-old plants bolting or producing a seed stalk. If a control is effective in preventing seed production and can be uniformly applied every other year, eventually the seed bank will be exhausted and no new plants can come up.

Perennials such as Russian knapweed and leafy spurge are most effectively controlled shortly before or after the first major killing frost in the fall. At that time sugars are being stored in root systems for winter survival and herbicide applications even at reduced rates still take advantage of this natural translocation period.

The principle change we have made in the past 20 years in weed management has been the focus on the establishment of perennial grasses and forbes. Several examples of revegetation replacing various weed problems have been done in Wyoming. These same problems are not as dominant in the eastern part of the U.S., but the principles of revegetation are very similar. Leafy spurge is a deep-rooted perennial that

dominates over 3 million acres in the northern U.S. It is now adapting to areas of New Mexico and the Midwest. Solid stands near the Devil's Tower close to Sundance, Wyoming have been controlled with perennial grasses such as Luna Pubescent Wheatgrass and Bozoisky Russian Wildrye for 12 years without herbicides, only grass competition. Grasses establish best in firm Me seedbeds with seeding depths less than 1/4 inch.

Perennial weeds such as Canada thistle grow best on moist soils near waterways and drainages. Grasses such as Regar brome are much better adapted in these sites which have higher moisture. Perennial bromegrasses are more effective competitors on highly productive sites. Dalmatian toadflax,a newcomer in the western U.S. is spreading rapidly on various disturbed sites. This species can be controlled following a killing frost with 1 quart of Tordon or 0.5 lbs active ingredient (a.i.) of picloram/acre. Grasses seeded in early spring before toadflax can reestablish itself have been very competitive for the past three years following establishment. With an integrated approach using insects for maintenance or retreating areas with a herbicide, grasses can be maintained for an indefinite period of time.

Russian knapweed is found on sites having shallow water tables such as river bottoms or irrigation canals. Control of this perennial weed species can be done following a killing frost in autumn using herbicides such as Tordon or picloram at rates of 1 pint to 1 quart or 0.25 to 0.5 lbs ai/acre, Transline at 14 fluid ounces/acre or Curtail at 2 quarts/acre. These applications should be followed by reseeding grasses such as Bozoisky Russian Wildrye or Luna Pubescent Wheatgass in the spring.

Studies conducted on dry sites such as Riverside, Wyoming, receiving less than 10 inches of precipitation each year show us that seeding Luna Pubescent Wheatgrass, Hycrest Crested Wheatgrass and Sodar Streambank Wheatgrass will effectively control downy brome, an annual, as well as musk thistle (a biennial).

On weed competition studies conducted on public lands such as the Grand Teton National Park revegetation is limited to the use of only native perennial species. Research studies are beginning in parks and on public land with native grass species such as thickspike wheatgrass, Idaho fescue, western wheatgrass, bluebunch wheatgrass, mountain brome, slender wheatgrass and big bluegrass.

In the future we need to continue using a systems approach for weed management, including insects, along with herbicides and grass competition to limit the spread of weeds on public areas and rights-of-way. We all have a lot to learn but I feel very committed to using a systems approach rather than a single tool approach such as a herbicide to provide long-term weed management.

Control of Downy Brome (*Bromus tectorum* L.) with

Herbicides and Perennial Grass Competition [1]

TOM D. WHITSON and DAVID W. KOCH[2]

Abstract. Long-term control of downy brome with an integrated approach is needed in order to sustain range productivity. Studies were conducted to study the effectiveness of a combination of downy brome control practices. In two studies, glyphosate and paraquat were evaluated at various rates for up to three successive years for control of downy brome in rangeland. A third study evaluated the competitiveness of perennial cool-season grasses against downy brome in the absence of herbicides. Glyphosate at 0.55 kg/ha and paraquat at 0.6 kg/ha provided selective downy brome control on rangeland when applications were combined with intensive grazing. Downy brome control was higher than 90% following two sequential years of paraquat at 0.6 kg/ha at either the two to eight leaf stage or bloom stage at both study locations. At one study location, glyphosate at 0.55 kg/ha provided 97% control after the first application at both growth stages. In the second study, control averaged greater than 92% following three sequential applications of glyphosate. When perennial cool-season grasses were seeded in the spring following fall tillage (no herbicides) and allowed to establish for three growing seasons, three of the five species were effective in reducing the re-establishment of downy brome. 'Luna' pubescent wheatgrass, 'Hycrest' wheatgrass, 'Sodar' streambank wheatgrass, 'Bozoisky' Russian wildrye and 'Critana' thickspike wheatgrass controlled 100, 91, 85, 45, and 32% of the downy brome, respecively. Yields of perennial grass dry matter were 1714, 1596, 1135, 900, and 792 kg/ha. Replacing non-competitive perennial grasses with competitive cool-season perennials will provide a longer term solution to a downy brome problem than the use of herbicides alone or with intensive grazing. **Nomenclature:** glyphosate (N-phosphonomethyl); glycine; paraquat (1, 1'-dimethyl-4,4'-bipyridinium ion); Bromus tectorum L. #3 BROTE; 'Luna' pubescent wheatgrass (*Thinopyrum intermedium* Host. Barkworth & Dewey); Nevski; 'Critana' thickspike wheatgrass, (*Elymus lanceolatus* Scribn. & Smith) Gould; 'Bozoisky' Russian wildrye, (*Psathyrostachys juncea* (Fisch) Nevski); 'Sodar' streambank wheatgrass, (*Elymus lanceolatus* (Scribn. & J.G. Smith) Gould; 'Hycrest' crested wheatgrass (*Agropyron cristatus* (L.) Gaertn.)x (*Agropyron desertorum* (Gaertn.)).

Additional index words: plant competition, rangeland weed control, annual grass control in rangeland, cool-season grasses.

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INTRODUCTION

Downy brome (*Bromus tectorum* L. #3 BROTE[3]) was introduced into North America from Europe in about 1850 (Murry et al. (1978)). It was identified in New York and Pennsylvania in 1861 (Hitchcock 1950). Downy brome was estimated to cover pproximately 24 million hectares of rangeland in the 11 western United States in 1965 (Hull 1965). It has continued spreading since the 1965 estimate and occupies land from the Thompson Valley in British Columbia, Canada to North Dakota, then south to northern Texas. Infestations are found in the entire western region of the United States (Morrow and Stahlman, 1984). Young and Evans (1973) observed in Nevada that once downy brome populations were established, they dominated the rangeland plant community. Daubenmire, in 1970, determined that once downy brome was established in western rangeland, it became a naturalized part of the vegetative community. Morrow and Stahlman (1984) concluded that it will become the predominant species within five years after establishment in disturbed areas.

Downy brome is utilzed as a high quality forage in early spring, but the grazing period is short because of its early maturation. Crude protein levels drop from about 12 to 15% to approximately 3% when downy brome reaches maturity (Cook and Harris, 1952). Stiff awns on mature plants which aid in downy brome seed dissemination, cause mouth and throat irritations in livestock (Mack, 1981). New growth of downy brome is used by deer in the spring and fall and is comparable in preference to 'Paiute' orchardgrass (*Dactylis glomerata* L.), 'Luna' pubescent wheatgrass and Fairway crested wheatgrass (*Agropyron cristatum* [L.] Gaertn. (Austin et al. 1994).

Downy brome is extremely competitive and aggressive as a seedling plant and will displace native bluebunch wheatgrass [*Pseudoroegneria spicata* (Pursh) Love] on native rangelands (Johnson and Aguirre, 1991). In the Powder River Basin of northeastern Wyoming, Allen and Knight, (1984), studied changes in successional communities when rangelands were disturbed. Various annual weeds were found in the ecosystem, but downy brome caused the greatest successional reduction of native perennials in those areas. Even without disturbance or overgrazing, downy brome can become a dominant species. In studies on Anaho Island in northwestern Nevada which contains 750 acres of undisturbed and ungrazed land (established as a National Wildlife Refuge to protect birds) downy brome became established and dominated the native perennials (Svejcar and Tausch, 1991).

Short-term studies indicate that once downy brome dominates rangeland, an irreversible change takes place resulting in its dominance of the rangeland community. An 11-year study completed in 1992 by Hosten and West in central Utah indicated that following a fire, downy brome increased for a two-year period, then the area rapidly declined in downy brome for two years followed by a three year fluctuation in cover. In the final four years of the study, negligible stands of downy brome were found when increases of perennial grass cover occurred (Hosten and West, 1992).

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[3] Letters following this symbol are a WSSA-approved computer code from Composite List of Weeds, Revised 1989.

Downy Brome Control Studies

Only a limited number of herbicides have been used successfully to control downy brome before reseeding infested rangeland. Atrazine [2-chloro-4-(ethylamino)-6-(isopropylamino)-s-triazine] was applied by Evans and Young, (1977) at 1.12 kg/ha in September and October 1971 to degraded rangeland. Treated areas were seeded to intermediate wheatgrass (*Agropyron intermedium* (Host) Beauv.) and crested wheatgrass one year following atrazine application. Downy brome control ranged from 90 to 100% with atrazine applications prior to planting perennial grasses (Evans and Young 1977).

Selective control of downy brome was reported in 1992 with pronamide (3,5-dichloro(N-1,1-dimethyl-2-propynyl) benzamide] and glyphosate [N-(phosphonomethyl) glycine]. Repetitive applications of each herbicide were required to prevent reinvasions because of downy brome's three-year seed longevity (Ogg, 1992).

In 1990, Young and Tipton conducted spring grazing studies to control downy brome. Sustained grazing reduced perennial grasses without controlling downy brome. The exclusion of livestock for 13 years resulted in greater infestations of downy brome (West et al. 1984). A 30-year study with a similar outcome was reported by Robertson, 1971.

Stands of antelope bitterbrush (*Purshia tridentata* (Pursh) DC) (an excellent wildlife habitat species) have been eliminated in Utah, Idaho, Oregon and California by fire cycles caused by fuel created by downy brome infestations (Mansen and Shaw, 1994).

In 1971, Klemp and Hull demonstrated the replacement of downy brome with competitive, desirable, cool-season perennial grasses. In that study, downy brome infested land was tilled in the spring and perennial grasses were seeded the following fall. The second year following seeding, Fairway crested wheatgrass (*Agropyron cristatum* (L.) Gaertn) and Siberian crested wheatgrass (*Agropyron Sibircum*) (Wild.) Beauv.) produced yields of 1327 kg/ha and 1944 kg/ha respectively, in areas once dominated by downy brome.

METHODS AND MATERIALS

Three studies were conducted on downy brome dominated rangeland near Kaycee, Lusk, and Riverside, WY. Studies at Kaycee and Lusk were conducted to determine if three successive applications of glyphosate and paraquat could reduce the soil seed bank of downy brome and create a competitive dominance of perennial grasses present in the rangeland understory. The study near Riverside, WY, was conducted to determine if cool-season perennial grasses could be established and effectively compete with downy brome.

Downy brome-infested rangeland plots near Lusk and Kaycee, WY were sprayed one, two or three successive years with four application rates of paraquat or three rates of glyphosate at two growth stages. At Lusk, treatments were applied April 25, 1991, April 21, 1992 and May 13, 1993 to downy brome in the 2 to 8 leaf stage, and on May 29, 1991, May 8, 1992 and June 9, 1993 to downy brome in the bloom stage. At Kaycee, treatments were applied April 9, 1991, April 23,

1992 and April 29, 1993 to downy brome in the 2 to 8 leaf stage and May 17, 1991, May 6, 1992 and June 11, 1993 to downy brome in the bloom stage. Treatments were applied with a tractor mounted sprayer delivering 60 L of water/ha at 270 kPa. Paraquat was applied with a 0.25% non-ionic surfactant. Soils at Lusk, WY were a Boyle sandy loam (a loamy-skeletal, mixed, shallow Aridic Argiborollos) containing 60% sand, 24% silt and 16% clay with 1.7% organic matter and a pH of 6.9; at Kaycee, WY the soil was a Moret loam (a loamy, mixed, non-acid mesic Lithit Ustic Torriorthent) containing 47% sand, 32% silt, and 21 % clay with 3.1% organic matter and a pH of 7.4. Herbicides were applied to blocks 11 by 335m containing four permanently located random transacts. Within each transect, 100 live canopy point readings were taken with Levy and Maddens point method of pasture analysis (Carter 1962). The point-frame containing 10 equidistant points spaced at 5 cm was located at ten 0.8-m intervals on a permanent 11-m transect line. Four-hundred pinpoint species identifications were taken following the third year treatment on July 28-30, 1993. Precipitation received in 1991, 1992 and for the first 6 months of 1993, was 41.5, 35.5 and 18 cm, respectively at 13 Lusk and 36.5, 35.5 and 19 cm, respectively at Kaycee. Thirty days following the herbicide application, cattle grazed intensively on both study sites for 90 days at Kaycee, WY and 80 days at Lusk, WY. Blue grama was estimated to be 60% utilized at both locations. The downy brome at Lusk, WY treated with paraquat at 0.5, 0.7 and 0.9 kg/ha was ungrazed the first year of the study.

A third study near Riverside, WY was established to determine if perennial cool-season grasses could compete with downy brome. The pasture site had been farmed at one time but was not reseeded to perennial grasses, therefore, it contained no perennial understory, only downy brome and musk thistle (*Cardus nutans* L.) The study was rototilled one time 8 cm deep August 23, 1993. Five perennial cool-season grass species were seeded on May 3, 1994 which included 'Critana' thickspike wheatgrass; 'Bozoisky' Russian wildrye; 'Sodar' streambank wheatgrass, Gould; 'Luna' pubescent wheatgrass and 'Hycrest' crested wheatgrass.

All species were seeded at 11 kg/pls/ha except Russian wildrye, which was seeded at 6 kg/pls/ha. Soils are an association of fine-loamy, mixed, frigid Ustic Haplargids and coarse-loamy, mixed, frigid Haplocalcids, with 73% sand, 12% silt and 15% clay containing 1.7% organic matter and a pH of 6.9. Precipitation was 45 cm in 1994, 41 cm for 1995 and 18 cm for the first six months of 1996. Perennial grasses and downy brome were harvested within each of the treatments by species from four random 0.25 m² quadrats. Species were oven-dried at 70°C for 48 hours and dry weights were used for comparisons. Plots 6.8 by 16m were replicated four times. All data from the three experiments were subjected to ANOVA. Means were separated with General Linear Procedures LSD test, P = 0.05.

RESULTS AND DISCUSSION

The efficacy of herbicide treatments was determined about six weeks following the last herbicide application at Lusk (Table 1). At Lusk, WY all treatments provided highly significant reductions of downy brome except paraquat at 0.6, 0.8 and 1.0 kg/ha applied one and two years which were ungrazed in year 1 (Table 1). Western wheatgrass, a cool-season perennial, was unchanged by any treatment; but blue grama, a warm-season perennial understory species, had a higher recorded canopy cover following the removal of the overstory species downy brome. Forb

density increased when glyphosate at 0.83 kg/ha was applied at the 2 to 8 leaf downy brome growth stage for three consecutive years. Forbs increased in areas treated at the later timing for three successive years with paraquat at 0.9 kg/ha or with a single glyphosate application at 0. 83 kg/ha also with two glyphosate applications of .55 kg/ha. The amount of bare ground increased in the 2 to 8 leaf application stage using glyphosate at 0.42 and 0.69 kg/ha when it was applied three successive years. A similar increase in bare ground was found at the early bloom application with a single application of paraquat at 1.2 kg/ha and with glyphosate applied three years at 0.69 kg/ha and two and three years at 0.83 kg/ha.

At Kaycee, WY, all paraquat treatments except the single 1.2 kg/ha application significantly reduced downy brome. Also, increases of downy brome were found in areas receiving single applications of glyphosate at 0.42 and 0.83 kg/ha along with a two year application at 0.83 kg/ha (Table 2). These differences were found in areas having lower perennial understories of blue grama, which provided less competition, therefore downy brome was released. Applications of glyphosate greater than 0.69 kg/ha caused a reduction in the stands of perennial grasses. When applied at the early bloom stage for three growing seasons, applications of glyphosate at 0.42 and 0.69 kg/ha failed to provide significant control of downy brome. Overall, paraquat was more effective than glyphosate for downy brome control when applied at early bloom.

Needle and thread (*Stipa comata Trin.* + Rupr.), a cool-season perennial, increased in nine of the 24 treatments applied in the 2 to 8 leaf stage and in ten of the 24 treatments at the early bloom application. The second cool-season perennial, western wheatgrass, decreased in all treatments except with glyphosate at 0.42 kg/ha applied at the 2 to 8 leaf stage. No decrease of downy brome was found in that treatment indicating that grazing preference was lower, similar to the untreated control. Annual forbs increased significantly in 12 of the 24 treatments applied in the 2 to 8 leaf stage while only three treatments showed increases when downy brome was treated at early bloom. Bare ground increased in treatments applied at the 2 to 8 leaf stage receiving three yearly paraquat applications at 0.8, 1.0 and 1.2 kg/ha or three applications of glyphosate at 0.83 kg/ha. When applications were made at early bloom, paraquat applied three times at 1.0 and 1.2 kg/ha had increases in bare ground along with single and two year applications of paraquat at 1.2 kg/ha. All glyphosate applications made at early bloom for three consecutive years had increases of bare ground. Herbicides applied at the 2 to 8 leaf stage were often followed by a second flush of downy brome resulting in less consistent control. Glyphosate at 0.69 kg/ha or above resulted in a reduction of the perennial grasses available for downy brome competition. Applications were made with a boom sprayer and the pastures often contained holes from rodents causing uneven boom heights which might also explain some inconsistencies in results. Current unpublished research applied with an airplane has resulted in very consistent, uniform control.

At Riverside, WY, five cool-season grasses were seeded into infestations of downy brome and were harvested by species at the end of the third growing season (Table 3). 'Luna' pubescent wheatgrass, 'Hycrest' crested wheatgrass and 'Sodar' streambank wheatgrass provided significant competition effectively reducing downy brome. 'Luna' pubescent wheatgrass and 'Hycrest' crested wheatgrass produced greater yields than areas seeded with 'Critana' thickspike wheatgrass,

'Bozoisky' Russian wildrye or 'Sodar' streambank wheatgrass. 'Sodar' streambank wheatgrass had a slightly higher percentage reduction of downy brome than those areas seeded to 'Hycrest' crested wheatgrass.

In conclusion, paraquat or glyphosate applied only one year failed to provide long-term control of downy brome. When treatments are left ungrazed, complete removal of downy brome seed heads is not accomplished and lower downy brome control can be expected. Perennial grass increases are found when downy brome is controlled. Rangeland will be utilized properly only following the removal of downy brome.

Table 1. Percent live canopy of downy brome infested rangeland following one, two and three annual applications of paraquat and glyphosate. (Lusk, WY)

Treatment[1]	Rate	Year	BROTE[2] 2.8 lf	BROTE[2] EB	AGRSM 2-8 lf	AGRSM EB	BOUGR 2-8 lf	BOUGR EB	Misc forb 2.8 lf	Misc forb EB	Bare G 2-8 lf	Bare G EB
	kg/ha		Percent live canopy cover[3]									
Paraquat[4]	0.6	1991	0	41	3	0	76	32	2	3	16	10
Paraquat	0.6	1991, 1992	0	55	7	1	86	31	2	1	21	10
Paraquat	0.6	1991,1992,1993	0	17	5	0	72	53	2	6	21	17
Paraquat	0.8	1991	4	34	14	0	58	30	3	2	21	18
Paraquat	0.8	1991,1992	1	49	2	4	75	29	4	5	17	12
Paraquat	0.8	1991,1992,1993	0	2	4	8	81	64	1	7	14	14
Paraquat	1.0	1991	0	37	4	0	74	40	3	3	16	11
Paraquat	1.0	1991,1992	0	38	0	0	78	42	6	9	13	7
Paraquat	1.0	1991,1992,1993	0	3	1	0	82	74	2	12	15	10
Paraquat	1.2	1991	0	1	8	10	70	54	2	4	20	32
Paraquat	1.2	1991,1992	0	0	7	2	71	67	3	9	19	21
Paraquat	1.2	1991,1992,1993	0	0	6	0	77	81	1	4	16	15
Glyphosate	.42	1991	2	1	3	15	69	60	5	3	21	20
Glyphosate	.42	1991,1992	0	1	2	6	75	83	6	1	17	9
Glyphosate	.42	1991,1992,1993	0	0	4	12	57	64	6	7	33	16
Glyphosate	.55	1991	1	0	5	10	62	75	9	5	21	11
Glyphosate	.55	1991,1992	0	0	0	5	85	72	2	11	13	11
Glyphosate	.55	1991,1992,1993	0	0	0	2	83	76	5	8	12	14
Glyphosate	.69	1991	0	9	4	9	75	60	6	4	16	13
Glyphosate	.69	1991,1992	0	1	3	9	79	56	5	5	11	18
Glyphosate	.69	1991,1992,1993	0	0	5	5	60	53	6	6	29	35
Glyphosate	.83	1991	0	3	1	6	77	47	7	12	14	27
Glyphosate	.83	1991,1992	0	1	1	3	81	45	5	9	11	31
Glyphosate	.83	1991,1992,1993	0	0	0	2	75	50	13	6	13	30
Check	--	-------	43	43	0	0	37	37	5	5	14	14
LSD Alfa	0.05		14	14	11	11	25	25	6	6	14	14
LSD Alfa	0.01		19	19	15	15	32	32	7	7	18	18

[1]Treatments applied April 25, 1991, April 21, 1992, May 13, 1993 to downy brome in the 2 to 8 leaf stage, May 29, 1991, May 8, 1992, June 9, 1993 to downy brome in the mid-bolting to early bloom stage.

[2]BROTE - *Bromus tectorum*, AGRSM - *Agropyron smithii*, BOUGR - *Bouteloua gracilis*, Misc. forb - miscellaneous forbs, Bare G. - Bare ground, 2-8 lf - 2 to 8 leaf, EB - early bloom stage for downy brome.

[3]Weed control live canopy based on 400 point frame counts/treatment, July 16-17, 1993.

[4]Paraquat applied at 0.5, 0.7 and 0.9 lb ai/A during early bloom were ungrazed, therefore, downy brome control was reduced.

Table 2. Percent live canopy of downy brome infested rangeland following one, two and three annual applications of paraquat and glyphosate. (Kaycee, WY)

Treatment[1]	Rate	Year	BROTE[2] 2.8 lf	EB	STICO 2-8 lf	EB	BOUGR 2-8 lf	EB	AGRSM 2.8 lf	EB	Misc forb 2-8 lf	EB	Bare G 2-8 lf	EB
			Percent live canopy cover[3]											
Paraquat	0.6	1991	11	18	37	31	18	20	2	2	7	7	22	18
Paraquat	0.6	1991, 1992	3	3	31	36	28	25	1	1	8	6	25	28
Paraquat	0.6	1991,1992,1993	1	1	20	37	36	31	1	0	7	3	29	28
Paraquat	0.8	1991	13	5	27	38	37	23	0	2	4	3	16	28
Paraquat	0.8	1991,1992	4	8	24	24	38	20	2	2	9	12	20	30
Paraquat	0.8	1991,1992,1993	1	0	26	40	24	26	1	1	10	5	32	29
Paraquat	1.0	1991	15	8	41	28	10	29	2	1	5	3	24	30
Paraquat	1.0	1991,1992	2	1	34	40	11	17	1	2	14	8	31	30
Paraquat	1.0	1991,1992,1993	0	0	16	37	26	22	0	0	9	3	35	37
Paraquat	1.2	1991	36	7	19	29	16	26	2	1	6	2	18	32
Paraquat	1.2	1991,1992	17	1	33	39	16	21	1	0	16	5	13	33
Paraquat	1.2	1991,1992,1993	1	0	10	28	31	30	1	0	7	4	40	38
Glyphosate	.42	1991	44	30	20	16	7	15	12	10	4	3	13	25
Glyphosate	.42	1991,1992	19	17	29	31	14	0	9	1	5	4	24	26
Glyphosate	.42	1991,1992,1993	22	3	30	22	23	28	3	1	4	2	19	44
Glyphosate	.55	1991	21	13	26	30	21	26	8	1	6	2	18	26
Glyphosate	.55	1991,1992	9	12	33	29	27	22	0	4	9	5	18	28
Glyphosate	.55	1991,1992,1993	1	4	33	24	36	26	1	7	7	1	18	38
Glyphosate	.69	1991	10	38	27	12	34	15	3	11	9	4	17	19
Glyphosate	.69	1991,1992	9	19	35	21	25	16	0	9	11	8	20	26
Glyphosate	.69	1991,1992,1993	10	2	35	26	9	14	1	6	16	2	29	48
Glyphosate	.83	1991	38	23	26	25	7	21	3	3	15	3	11	21
Glyphosate	.83	1991,1992	31	14	13	35	9	17	2	5	22	2	20	21
Glyphosate	.83	1991,1992,1993	8	0	23	27	13	20	1	1	16	2	34	49
Check	–	——	33	33	18	18	14	14	18	19	2	1	15	15
LSD Alfa	0.05		15	15	13	13	21	21	6	6	4	4	17	17
LSD Alfa	0.01		19	19	17	17	28	28	7	7	5	5	23	23

[1]Treatments applied April 9, 1991, April 23, 1992 and April 29, 1993 downy brome 2 to 8 leaf stage, May 17, 1991, May 6, 1992 and June 11, 1993 downy brome early bloom.

[2]BROTE - Bromus tectorum, STICO - Stipa comata, Bougr - Bouteloua gracilis, AGRSM - Agropyron smithii, Misc. forb - miscellaneous forbs, Bare G. - Bare ground, 2-8 lf - 2 to 8 leaf, EB - Early Bloom.

[3]Weed control live canopy based on 400 point frame counts/treatment, July 28-30, 1993.

Table 3. The competitive effects of five perennial cool-season grasses on downy brome.

	Perennial Grass	------- Downy Brome -------	
Perennial grass	kg (DM)/A	kg (DM)A	% reduction
(Critana) thickspike wheatgrass	792	913	32
(Bozoisky) Russian wildrye	900	737	45
(Sodar) streambank wheatgrass	1135	207	85
(Luna) pubescent wheatgrass	1714	0	100
(Hycrest) crested wheatgrass	1596	124	91
unseeded control	---	1337	0
LSD Alfa = 0.05	639	696	--

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INTEGRATED CONTROL OF LEAFY SPURGE (*EUPHORBIA ESULA*) AND RUSSIAN KNAPWEED (*CENTAUREA REPENS*) WITH PERENNIAL GRASS SPECIES

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ABSTRACT

Studies were initiated in Wyoming, USA to determine the potential of grass competition as an alternative to repetitive herbicide treatment for control of leafy spurge (*Euphorbia esula*) and Russian knapweed (*Centaurea repens*). An experiment was established to evaluate the effects grass species on leafy spurge. Russian wildrye cv. Bozoisky (*Psathyrostachys juncea*) and pubescent wheatgrass cv. Luna (*Agropyron intermedium var. trichophorum*) maintained 89 to 99% leafy spurge control four years after establishment. Studies were also started to determine the effects of five grass species on Russian knapweed. Applications of clopyralid plus 2,4-D and picloram, applied to Russian knapweed during the first frost, reduced Russian knapweed from an average of 44% in untreated unseeded plots to 10 to 12% live canopy cover in treated plots. Grass cover increased from an average of 6% in untreated seeded plots to 22 to 23% in plots treated with clopyralid plus 2,4-D and picloram.

INTRODUCTION

Leafy spurge and Russian knapweed are difficult to control perennials found throughout the western United States. They compete with desirable forage and are of no value to cattle producers. Picloram has proved to be the most reliable and effective herbicide for control of leafy spurge with a single application (Vore and Alley, 1982). However, control can be maintained for only three to five years. After this time a retreatment program must be implemented to maintain adequate leafy spurge control. Control is adequate when leafy spurge is suppressed to a level where cattle will be able to effectively utilize desirable forage growing in competition with leafy spurge. Hein (1988) found leafy spurge canopy cover exerted the greatest influence on grazing behavior and forage utilization by cattle. Leafy spurge canopy cover of 10% or less and shoot control of 90% or more were necessary to achieve 50% forage utilization by cattle in Montana (Hein, 1988). In North Dakota, leafy spurge infestations were avoided until early fall when the milky latex in the spurge subsided (Lym and Kirby, 1987). Cattle only used 2 percent of the available forage in leafy spurge densities of less than 20% cover.

Although herbicides play an important part in the control of leafy spurge and Russian knapweed alternative methods are available and may be used where persistent herbicides cannot be tolerated. One such method is plant competition. Grass competition has long been recognized as a method of weed control. Crested wheatgrass has been used successfully in Saskatchewan, Canada to decrease the rate of vegetative spread, limit density, reduce seed production and suppress top growth of leafy spurge (Selleck, 1959). Leafy spurge growth may also be suppressed by planting an early emerging crop such as crested wheatgrass, that will compete with it for early soil moisture (Morrow, 1979).

Russian knapweed is highly competitive on disturbed sites and severely reduces land values. Russian knapweed is also allelopathic. Therefore, areas must be tilled before newly established grass seedlings can survive. Without tillage grass seedlings can survive only after Russian knapweed residues have been exposed to moisture for two growing seasons.

Grasses selected for these studies were pubescent wheatgrass cv. Luna, Russian wildrye cv. Bozoisky, thickspike wheatgrass cv. Critana (*Agropyron dasystachyum*), streambank wheatgrass cv. Sodar (*Agropyron dasystachyum riparium*), crested wheatgrass cv. Hycrest (*Agropyron cristatum*), and western wheatgrass cv. Rosana (*Agropyron smithii*).

The purpose of this research was to determine the potential of perennial grass competition as an alternative to repetitive herbicide treatment for control of leafy spurge or Russian knapweed.

MATERIALS AND METHODS

Studies were established near Devil's Tower in Crook County, Wyoming. Grasses included in the study were pubescent wheatgrass cv. Luna and Russian wildrye cv. Bozoisky. Grasses were selected from a previous study on the basis of productivity, ability to establish in low precipitation areas and ability to compete with leafy spurge. The study area received only natural precipitation.

Glyphosate was applied before seeding grasses in 1989 to control existing vegetation. Plots (10 by 53 m) were arranged in a randomized complete block design with two factors and four replications. Factors were grass varieties and till versus notill. Plots were rototilled and rolled on 7 August, 1989. Grasses were seeded at 64 mm with a double-disc opener Tye drill on 8 August, 1989. Luna was seeded at a rate of 12 kg and Bozoisky at a rate of 8 kg of pure live seed per ha. Row spacing was 20 cm for both varieties. Postemergent applications of 2,4-D and metsulfuron plus 2,4-D were made in 1989 and 1990 to control annual broadleaf weeds. Percent leafy spurge control, number of grass plants per 6 m of row, and kg of air dry grass per ha were taken 12 and 13 September, 1991, 8 July, 1992 and 28 September, 1993.

Two studies were also located on Lander Complex sandy loam soils near Riverton and Ft. Washakie, Wyoming and were treated with herbicides on 10 and 11 October, 1991. Plots were tilled with a rototiller October 20, 1991. Metsulfuron (8.5 g ai/ha), clopyralid (0.3[illegible] ai/ha) plus 2,4-D (1.65 kg ai/ha), and picloram (0.28 kg ai/ha) were applied in August, 1992. [illegible] herbicides, except picloram, were reapplied in August, 1994. Russian knapweed had started into winter dormancy during the 1991 application and in late bloom in 1992 and early bloom in 1994. Plots were seeded with streambank wheatgrass cv. Sodar, thickspike wheatgrass cv. Critana, crested

wheatgrass cv. Hycrest, western wheatgrass cv. Rosana and Russian wildrye cv. Bozoisky at 11.2 kg pure live seed/ha, except Russian wildrye which was seeded at 6.6 kg/ha on 11 and 12 April, 1992.

RESULTS AND DISCUSSION

Leafy spurge control was excellent at 89% or better in both rototilled and no-till plots for all years for both grasses (Table 1). The tilled plots had significantly more plants per 6 m of row than the no-till plots for both grasses in 1991 (Table 1). In 1992 there was a considerable increase in plants in the Bozoisky plots (Table 1).

Table 1. Pubescent wheatgrass (Luna) and Russian wildrye (Bozoisky), September 1991 (91), July 1992 (92) data and September 1993 (93) data.

	Leafy spurge control (%)						Grass plants/6 m of row					
	Till			No-till			Till			No-till		
Variety[1]	91	92	93	91	92	93	91	92	93	91	92	93
Luna	99	99	99	99	99	96	34	34	37	25	27	28
Bozoisky	99	99	96	95	97	89	37	56	54	21	28	28
LSD-5%[2]	3	5	ns	3	5	ns	5	11	7	5	11	7

[1]Grasses seeded August 8, 1989.
[2]Comparison of variety means is valid between till and no-till, within years.

Grass production for 1991 was very good for both the till and no-till plots due to good early season moisture. In the tilled plots Luna provided 3440 kg of air dry forage per ha and 2445 kg in the no-till plots (Table 2). Bozoisky production was 1640 kg in the tilled plots and 1173 kg in the no-till plots. In 1992 and 1993 forage production was also very good (Table 2). There were no differences between production in the tilled versus the no-till plots in 1992. There was a significant increase in forage production for Luna plots in the tilled plots compared to the no-till plots in 1993.

Table 2. Pubescent wheatgrass (Luna) and Russian wildrye (Bozoisky), September 1991 (91), July 1992 (92) data and September 1993 (93) data.

	Grass production (kg/ha)					
	Till			No-till		
Variety[1]	91	92	93	91	92	93
Luna	3440	2378	3638	2445	2394	2993
Bozoisky	1640	1550	1349	1173	1369	1249
LSD-5%[2]	803	493	337	803	493	337

[1]Grasses seeded August 8, 1989.
[2]Comparison of variety means is valid between till and no-till, within years.

Luna was developed in New Mexico by the USDA/SCS (Onsager, 1987). It had excellent establishment, leafy spurge control, and forage production in both the till and no-till plots. Bozoisky has been significantly more productive and easier to establish on semiarid range sites than other Russian wildryes (Onsager, 1987). It had excellent leafy spurge control and good forage production in the till and no-till plots. Luna and Bozoisky appear to be good grasses for competition with leafy spurge and other weedy species.

Russian knapweed live canopy cover was reduced from an average of 44% in the untreated unseeded checks to 10% in the areas treated with clopyralid plus 2,4-D (Table 3). There was no difference between grass varieties when compaired to % Russian knapweed cover. Reductions to 2% live canopy cover of Russian knapweed were obtained with a single application of picloram.

Table 3. Russian knapweed (Knap) % live canopy cover, Ward (Wd) and Brown ranch (Br).

	Treatment										
	Metsulfuron		Clopyralid+2,4D		Picloram		Untreated unseeded		Untreated seeded		
Grass	Wd	Br	Wd	Br	Wd	Br	Wd	Br	Wd	Br	Mean
Streambank wheatgrass	33	41	14	3	13	6	28	54	20	43	25
Thickspike wheatgrass	40	49	13	5	20	2	33	59	30	53	30
Crested wheatgrass	47	24	14	4	22	2	32	55	23	48	27
Western wheatgrass	34	50	16	6	25	6	30	56	30	52	30
Russian wildrye	37	36	13	10	20	6	33	61	23	53	29
LSD (0.1)	15	15	15	15	15	15	15	15	15	15	
LSD (0.05)											4
Mean	39		10		12		44		37		
LSD (0.05) = 4											

Stands of the five perennial grasses averaged 22% live canopy cover in the clopyralid plus 2,4-D and 23% live canopy cover in the picloram treatment compared to 6% for the untreated seeded plots (Table 4). The two grasses having the greatest overall establishment were thickspike wheatgrass cv. Critana with an average over all treatments of 17% live canopy cover and streambank wheatgrass cv. Sodar with 16% live canopy cover. The lowest amount of Russian knapweed (2%) and the highest % live canopy of grass (47%) were found in plots treated with picloram and seeded to thickspike wheatgrass (Tables 3 and 4).

Table 4. Percnt grass live canopy cover, Ward ranch (Wd) and Brown ranch (Br).

	Treatment										
	Metsulfuron		Clopyralid+2,4D		Picloram		Untreated unseeded		Untreated seeded		
Grass	Wd	Br	Wd	Br	Wd	Br	Wd	Br	Wd	Br	Mean
Streambank wheatgrass	21	6	24	35	16	47	0	0	7	8	16
Thickspike wheatgrass	12	17	23	40	14	47	0	0	7	7	17
Crested wheatgrass	5	18	3	23	3	26	0	0	1	9	9
Western wheatgrass	5	9	9	29	5	30	0	0	6	6	10
Russian wildrye	8	13	16	19	10	30	0	0	2	5	10
LSD (0.05)	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	4
Mean LSD (0.05) = 4	11		22		23		0		6		

Critana thickspike wheatgrass and Sodar streambank wheatgrass are very similar grasses. They are native perennial grasses which can be used to vegetate and reduce erosion on disturbed sites such as mined lands, roadsides, recreation areas, and construction sites. Both are excellent for reseeding range sites that are severely eroded or that have low fertility. Both are also strongly rhizomatous and grow to 25 to 30 cm in height on good sites. They produce abundant, fine, light green leaves and form a tight sod under dryland conditions. Both have excellent seedling vigor and are adapted to medium- to coarse-textured soils. They are also adapted to soils derived from granulated shales and clays that behave like coarse-textured soils. They grow in the 25- to 51-cm precipitation zone in the northern Rocky Mountains and adjacent Great Plains regions. Both adapt to elevations ranging from 610 to 2287 m (USDA, 1984). These grasses had the greatest live canopy cover in the study.

Hycrest crested wheatgrass is a winter hardy, drought resistant bunchgrass. Although the new cultivar is well adapted to sagebrush and juniper vegetation sites (30 cm of annual precipitation), good to excellent stands have been established on shadscale, greasewood, and Indian ricegrass sites where annual precipitation is less than 20 cm. In southern areas, it is best adapted to elevations of 1500 m or more. The upper elevation limits are from 2590 to 2740 m. It performs well on a wide variety of soil types; however, it is particularly well adapted to sandy or sandy loam soils. In general, crested wheatgrass will not tolerate prolonged flooding and is only moderately tolerant of saline soils when compared to tall wheatgrass, quackgrass, or western wheatgrass (Asay and Horton, 1985).

Rosana western wheatgrass, a native perennial grass, was developed for reseeding depleted rangelands and abandoned cropland in Montana and Wyoming. Seedling vigor also makes Rosana a valuable grass for mine reclamation. The plants are blue-green, leafy, moderately fine stemmed, and easy to establish. Rosana is adapted to the moderately rolling topography of the northern Rocky Mountain region and the adjacent Great Plains. It does best on medium to fine textured soils and tolerates soils that are neutral to strongly alkaline. Rosana is adapted to areas with 30

or more cm of precipitation. Production is enhanced by extra moisture from irrigation or on overflow sites. Rosana forms a tight sod under dryland conditions. Rosana will produce excellent seed crops under irrigation (USDA, 1979).

Because of their performance in these studies Luna pubescent wheatgrass and Bozoisky Russian wildrye appear to provide effective competition with leafy spurge. Critana thickspike wheatgrass and Sodar streambank wheatgrass also appear to provide effective competition with Russian knapweed. There is a need for long-term research to confirm that these grasses or others will effectively compete with these weeds and reduce the amount of herbicides needed for control of perennial weeds.

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A SYSTEMS APPROACH FOR THE CONTROL OF RUSSIAN KNAPWEED

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ABSTRACT

Studies were initiated in Wyoming to determine the potential of grass competition as an alternative to repetitive herbicide treatment or other cultural practices for control of russian knapweed (*Centaurea repens*). An experiment was established to evaluate the effects of five grass species including russian wildrye. Applications of clopyralid plus 2,4-D and picloram, applied to russian knapweed during the first frost, reduced russian knapweed from an average of 80.1% live canopy cover which equates to 0% control. Untreated unseeded checks resulted in 83.9% and 81.1% control in tilled and non-tilled treated plots respectively. Grass cover increased in untreated seeded plots from an average of 11.3% and 8.2% in tilled and non-tilled plots, respectively, to 72.5% in tilled and 66% in non-tilled plots treated with clopyralid plus 2,4-D. Grass cover also increased 69.7% in tilled and 64% in non-tilled plots treated with picloram. There was no significant difference between grass varieties when compared to % russian knapweed cover. Reductions to 0% live canopy cover of russian knapweed were obtained with a single application of picloram. Economic feasibility thresholds were obtained from four out of five varieties including a significant difference provided by non-tilled russian wildrye treated with clopyralid plus 2,4-D.

INTRODUCTION

Russian knapweed, a perennial found throughout the western United States, is the most persistent of the knapweeds (Lacey, 1989) and is difficult to control. It competes with desirable forage and is of no value to cattle producers. Control can be maintained with single herbicide treatments for only three to five years, so after this time a re-treatment program must be implemented to maintain adequate control.

Although herbicides play an important part in the control of russian knapweed, alternative methods are available and may be used where persistent herbicides cannot be tolerated. This type of integrated weed management strategy is a multi-disciplinary, ecological approach to managing weed populations. There is no example of an extensive noxious weed infestation being eradicated by a single method (Lacey, 1991). Grass competition has long been recognized as a method of weed control. Crested wheatgrass has been used successfully in Saskatchewan, Canada to decrease the rate of vegetative spread, limit density, reduce seed production and suppress the growth of other perennial weeds.

Russian knapweed is highly competitive on disturbed sites and severely reduces land values. It is also allelopathic (Fletcher & Renney, 1963) so that areas must be tilled before newly established grass seedlings can survive. Without tillage, grass seedlings can survive only after russian

knapweed residues have been exposed to moisture for two growing seasons.

Biological control of weeds is the planned use of living organisms to reduce their vigor, reproductive capacity, density, or effect. This broad definition also encompasses competitive grass species (Quimby *et al.*, 1991). Wheatgrasses, fescues and wildryes are among the most commonly used for reseeding western rangelands. Selection of rhizomatous species is appropriate where noxious weeds are a consideration (Callihan & Evans, 1991). Grasses selected for these studies were russian wildrye, thickspike wheatgrass, streambank wheatgrass, crested wheatgrass, and western wheatgrass because of their potential to provide both a competitive and production incentive. Using a production approach, there is economic incentive to control knapweed (Feuz *et al.*, 1996) The purpose of this research was to determine the potential of perennial grass competition as an alternative to repetitive herbicide treatment and other cultural practices for control of russian knapweed.

MATERIAL AND METHODS

Studies were established on the Wind River Indian Reservation near Arapaho and Fort Washakie in Wyoming. Study sites were located on Lander Complex sandy loam soils using a split-split plot design and were treated with herbicides after frost on 10 and 11 October 1991. Plots were tilled in May 1991. Metsulfuron (8.5 g. ai/ha), clopyralid (0.32 kg ai/ha) plus 2,4-D (1.65 kg a.i./ha), and picloram (0.28 kg ai/ha) were applied in August 1992 using a CO_2 pressurized backpack sprayer at 121.4 litres/ha/kPa at 270 kPa with 8004 nozzles. All herbicides, except picloram, were reapplied in August 1994. Russian knapweed had started into winter dormancy during the 1991 application, was in late bloom in 1992 and early bloom in 1994. Plots were seeded on 11 and 12 April 1992 at 20 cm row spacing with a double- disc opener Tye drill with streambank wheatgrass, thickspike wheatgrass, crested wheatgrass, and western wheatgrass at 11.2 kg pure live seed/ha, except russian wildrye which was seeded at 40 cm and 6.6 kg/ha. Plots were mowed in the fall of 1996 to emulate grazing and allow for realistic measurement of 1997 spring regrowth.

RESULTS AND DISCUSSION

Russian knapweed live canopy cover was reduced from an average of 80.1% and this was equated to 0% control. Untreated unseeded checks resulted in 86.9% in tilled and 81.2% control in non-tilled, as well as 80.4% in tilled and 83.6% control in non-tilled treatments of picloram and clopyralid plus 2,4-D respectively (Tables 1 and 2). There was no significant difference between grass varieties when compared to % russian knapweed cover. Reductions to 0% live canopy cover of russian knapweed were obtained with a single application of picloram.

A vegetative inventory using Levy and Madden's point method of pasture analysis (Carter, 1962) was used to determine live species canopy cover. A point-frame containing 10 equidistant points spaced at 5 cm was located at ten 0.92-m intervals on a permanent 10.22-m transect line within each treatment replicate. Three hundred pin point species identifications were taken to determine the species inventories per treatment. Counts for each species were converted to a percentage of the live canopy cover. Point transect readings were taken of earlier 1995 evaluations having 70% knapweed control or better on June 17/18 1997 and June18/19 1997 at Arapaho and Fort Washakie, respectively. Only seeded treatments receiving picloram and clopyralid plus 2,4-D

averaging 98.1% and 93.9%, respectively, were evaluated in 1997. Burning (47%), mowing (50.6%) and metsulfuron (49.4%) treatments did not provide effective control.

Table 1. Percent Control of Russian Knapweed at Arapaho (AR) and Fort Washakie (FW)

Tilled % Control of Russian Knapweed

	Clopyralid		Picloram		Untreated/Seed	
Grass	AR%	FW%	AR%	FW%	AR%	FW%
Russian Wildrye	93	75	100	85	20	27
Crested Wheatgrass	*	*	91	51	25	18
Thickspike Wheatgrass	86	79	100	88	24	27
Western Wheatgrass	96	67	94	77	16	22
Streambank Wheatgrass	93	50	97	82	24	24
LSD (0.05)	11.6	39.6	11.8	20		
Mean	80		87		23	

1.Percent Knapweed control reflects untreated unseeded checks as 0.% control. counts/plot.
2.Herbicides were applied 10/91, 8/92, 3/94.
3.Grasses were seeded 4/92.
4.% Control was based on 100 point-frame
*Evaluations below 70% control in 1995 did not occur.

Table 2. Percent Control of Russian Knapweed at Arapaho (AR) and Fort Washakie (FW)

No-Till % Control of Russian Knapweed

	Clopyralid		Picloram		Untreated/Seed	
Grass	AR%	FW%	AR%	FW%	AR%	FW%
Russian Wildrye	94	72	100	87	.21	25
Crested Wheatgrass	*	*	95	58	23	29
Thickspike Wheatgrass	*	*	*	*	22	32
Western Wheatgrass	*	*	95	55	22	22
Streambank Wheatgrass	*	*	93	64	24	34
LSD (0.05)			7.1	32.9		
Mean	83		81		25	

1.Percent Knapweed control reflects untreated unseeded checks as 0.% control.
2. Herbicides were applied 10/91, 8/92, 3/94.
3. Grasses were seeded 4/92.
4. % Control was based on 100 point-frame counts/plot.
*Evaluations below 70% control in 1995 and did not occur.

Stands of perennial grasses averaged 69.7% live grass cover in tilled and 66.4% live grass cover in non-tilled picloram treatments and 65.6% live grass cover in tilled and 66.3% live grass cover in non-tilled treatments of clopyralid plus 2,4-D. This compared to 10.4% and 9.3% for the

untreated seeded tilled and non-tilled plots, respectively (Table 3 and 4). The two grasses with the highest overall establishment in tilled plots were streambank wheatgrass and thickspike wheatgrass with an average overall treatment of 76.6% live grass cover. The two grasses with the highest overall establishment in non-tilled plots were russian wildrye with 78.7% live grass cover and western wheatgrass with 65.8% live grass cover. The lowest amount of russian knapweed (0%) and the highest amount of live cover of grass (92.5% in non-tilled and 90% in tilled) were found in plots treated with picloram and seeded to russian wildrye (Tables 3 and 4).

Table 3. Percent grass cover at Arapaho (AR) and Fort Washakie (FW)

Tilled % Grass Cover

	Clopyralid		Picloram		Untreated/Seeded	
Grass	AR%	FW%	AR%	FW%	AR%	FW%
Russian Wildrye	81	52	90	55	8	6
Crested Wheatgrass	*	*	70	33	18	3
Thickspike Wheatgrass	68	65	83	70	14	17
Western Wheatgrass	80	48	81	60	5	6
Streambank Wheatgrass	88	41	85	68	16	20
LSD (0.05)	20.9	35.3	21	16.4		
Mean	65		69		11	

1.Percent Grass cover reflects untreated unseeded check with 1. 0% grass.
2.Herbicides were applied 10/91, 8/92, 3/94.
3.Grasses were seeded 4/92.
4.% Control was based on 100 point-frame counts/plot.
*Evaluations below 70% control in 1995 did not occur.

Table 4. Percent grass cover at Arapaho (AR) and Fort Washakie (FW)

No-Till % Grass Cover

	Clopyralid		Picloram		Untreated/Seeded	
Grass	AR%	FW%	AR%	FW%	AR%	FW%
Russian Wildrye	83	49	92	65	8	4
Crested Wheatgrass	*	*	78	43	10	5
Thickspike Wheatgrass	*	*	*	*	10	9
Western Wheatgrass	*	*	86	45	9	6
Streambank Wheatgrass	*	*	70	47	9	12
LSD (0.05)			24.1	26.4		
Mean	66		66		8	

1.Percent Grass cover reflects untreated unseeded check with 1.0.% grass
2.Herbicides were applied 10/91, 8/92, 3/94.
3.Grasses were seeded 4/92.
*Evaluations below 70% control in 1995 did not occur.

Forage samples were taken on June 17/18 1997 and June 18/19 1997 at Arapho and Fort Washakie, respectively, from 1 m^2 plots to evaluate yield and nutrient value. Research grasses averaged 489 kg/ha grass yield in tilled, and 1149 kg/ha grass yield in non-tilled clopyralid plus 2,4-D compared to 444 kg/ha grass yield in tilled and 500 kg/ha grass yield for picloram treatments (Table 5). All grasses with the exception of thickspike wheatgrass produced enough to reach an economic threshhold to warrant implementing a systems approach for the control of russian knapweed. The only significant treatment providing both yield and control was non-tilled russian wildrye treated with clopyralid.

Table 5. Grass yield at Arapaho (AR) and Fort Washakie (FW)

	Tilled				Non Tilled					
	Clopyralid		Picloram		Clopyralid		Picloram		Untreated/ Unseeded	
Grass (kg/ha)	AR%	FW %	AR%	FW %	AR%	FW %	AR%	FW %	AR %	FW%
Russian Wildrye	84	252	537	263	1492	805	1171	400	74	27
Crested Wheatgrass	*	*	1145	200	*	*	687	225	41	13
Thickspike Wheatgrass	527	289	480	244	*	*	*	*	*	*
Western Wheatgrass	885	213	618	191	*	*	804	259	48	16
Streambank Wheatgrass	668	237	401	260	*	*	263	193	35	12
LSD (0.05)	283	192	885	264			142	307	308	270
Mean	489		444		1149		500		33	

1.Herbicides were applied 10/91, 8/92, 3/94. 2.Grasses were seeded 4/92.
*Evaluations did not occur as they were below 70% control in 1995.

Critana thickspike wheatgrass and Sodar streambank wheatgrass are very genetically similar grasses. They are native perennial grasses which can be used to vegetate and reduce sites disturbed by erosion such as mined lands, roadsides, recreation areas, and construction sites. Both are excellent for reseeding range sites that are severely eroded or that have low fertility. Both are also strongly rhizomatous and grow to 25 to 30 cm in height on good sites. They produce abundant, fine, light green leaves and form a tight sod under dryland conditions. Both have excellent seedling vigor and are adapted to medium- to coarse-textured soils. They grow in the 25- to 51-cm precipitation zone in the northern Rocky Mountains and adjacent Great Plains regions. Both adapt to elevations ranging from 610 to 2287 m (USDA, 1981). These grasses gave the highest average percent live grass cover in the tilled study.

Hycrest crested wheatgrass is a winter hardy, drought resistant bunchgrass. Although the new cultivar is well adapted to sagebrush and juniper vegetation sites (30 cm of annual precipitation

or lower), good to excellent stands have been established on shadscale, greasewood, and Indian ricegrass sites where annual precipitation is less than 20 cm. In southern areas, it is best adapted to elevations of 1500 m or more. The upper elevation limits are from 2590 to 2740 m. It performs well on a wide variety of soil types, but is particularly well adapted to sandy or sandy loam soils. In general, crested wheatgrass will not tolerate prolonged flooding and is only moderately tolerant of saline soils when compared to tall wheatgrass, quackgrass, or western wheatgrass (Asay & Horton, 1985). This grass had the greatest live grass cover in non-tilled plots along with rosanna western wheatgrass.

Rosana western wheatgrass, a native perennial grass, was developed for reseeding depleted rangelands and abandoned cropland in Montana and Wyoming. Seedling vigor also makes it a valuable grass for mine reclamation. The plants are blue-green, leafy, moderately fine stemmed, and easy to establish and are adapted to the moderately rolling topography of the northern Rocky Mountain region and the adjacent Great Plains. It does best on medium to fine textured soils, tolerates soils that are neutral to strongly alkaline, and is adapted to areas with 30 or more cm of precipitation. Rosana forms a tight sod under dryland conditions, and will produce excellent seed crops under irrigation (USDA, 1979).

Because of their performance in these studies, russian wildrye, thickspike wheatgrass, crested wheatgrass, western wheatgrass and streambank wheatgrass appear to provide both a financial return and effective competition with russian knapweed when either clopyralid plus 2,4-D or picloram and specific tillage practices are applied.

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BLM Weed Page

National Weed Symposium

April 8-10, 1998

ABSTRACTS

IMPORTANCE OF RECLAMATION WITHIN AN INTEGRATED WEED MANAGEMENT PROGRAM

Cynthia J. Owsley, Boulder County Parks and Open Space, Boulder, County, Colorado

Reclamation is a frequently used term in noxious weed management, but few topics in the land management field are as broad in their scope of possibilities as reclamation. A widely accepted principle is that disturbed lands act as "magnets" for early noxious weed invasions. These sites are the first areas where noxious weeds colonize before they expand into undisturbed areas. A successfully reclaimed site reduces the open niche space that attracts the early colonization of noxious weeds, along with a host of other ecological benefits. Unfortunately, this is a very long process that can require as much as three to ten years to be established. For large acreages a cover crop is recommended before seeding grasses to provide erosion control and protection for developing seedling. A single mowing can be used as a management technique to control undesirable annual weeds. A Conservation Reserve Program reclamation site on sandy soils in Boulder County, Colorado illustrates the time and numerous inputs that are often required to successfully reestablish a native rangeland. After ten years, using two cover crops, three series of seed plantings, mowings, and herbicide treatments, this area is finally proving successful in its establishment. While not all reclamation projects will require such a dedication of time and resources, many of the arid lands throughout the west pose long term challenges for reclamation.

There is a common misconception that reclaiming with native grasses will repel future weed invasions. Given the highly invasive nature of most of the noxious species with which land managers are dealing, few western habitats can completely resist invasion. Whether native or introduced seeds are used on reclamation projects, it takes time before these sites are able to provide much competition against invading noxious weeds. It is critical to remove all noxious weeds before seeds are planted because seedlings are susceptible to many herbicide treatments during their first year. Just as integrated weed management requires a long term commitment, disturbed lands require ongoing maintenance beyond the initial reseeding to insure long term reclamation success.

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BLM Weed Page

National Weed Symposium

April 8-10, 1998

PROCEEDINGS

NATIONAL ALIEN SPECIES STRATEGY
Bill Brown, Science Advisor to the Secretary, Department of the Interior

Last summer a group of 500 scientists wrote the Vice President and asked him to make invasive alien species a national priority. Senators also wrote and urged the administration toward action. The Vice President directed the Secretaries of Interior, Agriculture, and Commerce, in consultation with CEQ and OSTP, to look at the issue of invasive alien species across the board. An interagency task force has developed a draft action plan that now encompasses animals, plants and other viable biological materials that could contribute to alien invasions.

After several meetings, some with over 100 agency representatives, it became clear last fall that not only did we need to involve people outside of federal government, we needed to launch a directive from the President addressing some of the fundamental elements of the strategy. We need to create a forum for planning and coordination that would fully involve government and the private sector. We turned our attention from a 25 page draft document, to a directive. The directive has five elements:

- To lay out federal responsibilities
- To establish a federal invasive species council
- To direct the council to develop a comprehensive management plan
- To have the council take concrete steps to address introductions and pathway interdiction of these organisms by a date certain
- To facilitate and support existing regional activities

Agencies need to have methods of control, and restrict the spread of organisms into other countries. Education is a key element. International cooperation is as well. There are treaties on many other issues, but not on invasive alien species. This would help direct the prevention and control of the spread of invasions into ecosystems.

The national council would consist of the Secretaries of Interior, Agriculture and Commerce. Included as founding members, though the council may grow, would be Defense, State, Transportation, Customs, and EPA. The expectation is that the heads of subcabinet agencies may also be named, such as BLM,

Park Service, FWS and Forest Service.

The council would be structured such that other government entities would be included by invitation. The private sector also. The council would be chartered as a FACA committee so that the non-federal council members could participate. Wide participation will add to the "buy in" of ideas generated by the council.

The national council duties would be to coordinate the activities of this initiative. The council would be charged with developing and documenting the ecological impacts and take responsibility for adding to that information. The council would promote web based systems that would integrate invasive aliens species into the databases of native species information that we have already.

The council would further develop and seek public comment on a draft action plan for national cooperation, regional development, and review the authorities needed. Then it would produce a national management plan that would be developed with the broad involvement of everyone that is interested in this issue. The plan would be reviewed in twelve months after the establishment of the council.

The plan would address all of the fundamentals: measurable goals, personnel and resources, report annually on the success and implementation, and revise the plan at least every two years. The plan would be submitted to OMB annually in the budget process. The desire is to lay out something very specific, including dates certain for accountability.

In addition, the matter of stopping alien species introduction into the United States should be specifically addressed. This recommendation is to have the national council suggest measures of control for intentional and unintentional introduction, as well as interdiction of major pathways.

We need to engage the broader public: the weed community, the aquatic animal and plant community. The government of Australia has implemented a system that involves 49 questions that need to be answered before something can come in. We may not need to implement something that comprehensive, but there are ways to go forward without slowing progress.

It is recommended that once the council launches measures, that the agencies with the authorities implement them; and that they be required to implement them within a specific time period; and have accountability.

On regional coordination: one suggestion was to frame a section to establish regional councils, but the counter argument said that we should facilitate and support the existing regional activities. Not be top down from the Washington Office. So the council will support existing regional activities and facilitate expanding their current activities.

It is difficult to know when this council will launch, but hopefully in the next few months. The draft action plan will be the way that the council begins.

BLM Weed Page

National Weed Symposium

April 8-10, 1998

ABSTRACTS

THE POWER OF COOPERATIVE WEED MANAGEMENT AREAS IN CREATING AN EFFECTIVE NOXIOUS WEED MANAGEMENT PROGRAM

Glen Secrist, Idaho State Department of Agriculture, Boise, Idaho

Idaho, like many states in the West, has a serious noxious weed problem. Often called a resource issue, it is in reality, like many "issues", mostly a "people" problem. Noxious weeds, like floods and wildfires, respect no ownership or jurisdictional boundaries. The negative impacts of noxious weeds are equally felt on private, state and federal lands. Likewise, the ability to turn the tide on noxious weeds will depend on the ability and willingness of local people of many stripes to work together under the umbrella of common goals, priorities, and genuine commitment. The best know and tested way to do this is through the mechanism of a Cooperative Weed Management Area (CWMA). Following any one of several existing models, the CWMA concept can unleash the creative power and action of local people. Real change rises up.

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Glen Secrist, Idaho State Department of Agriculture, Boise, Idaho

A young man, fresh out of agricultural college, and in his first few weeks as a sales representative for a fertilizer company, made an appointment with a prominent area farmer. After meeting at the farm, the two of them, talking as they went, looked at each of the farmer's fields and the crops he had planted. At each field, the young salesman would inquire about the typical yields that the farmer was producing and would explain to him how he could increase his production significantly by using a particular formulated fertilizer. How much wheat did you produce last year? the young man asked. Oh, about 80 bushel to the acre the farmer relied. By using our new fertilizer at the prescribed rate, you can jump production up to 100 bushels easily the young man assured him. And so it went, field-by-field, the salesman illustrating the increase that would be possible and why it was economically advantageous for him to purchase the fertilizer.

Upon arriving at the farmstead, the young man, wanting to close the sale, pulled out an order blank. I can have the fertilizer delivered in two days he said confidently, how much would you like to order? Stroking his chin, the farmer shocked him by saying that he guessed he wouldn't order any. I just don't understand it , said the young man, I've shown you how you can increase your yields for every crop. Yes you have said the farmer, but hell, I'm only farming half as good as I know how now!

I believe this is painfully similar to the weed management business - we're only doing half as good as we know how now. In our quest to find new tools and techniques for combating the spread of weeds, we often neglect some of the fundamental principles of any human endeavor after all it is through <u>people</u> (as opposed to dogs, monkeys, machines) that things get done. Here are some of these fundamentals principles that I believe will give us assure a greater likelihood of success as we work through people:

VISION
PLANNING
SIMPLICITY
PARTNERING
PERSISTENCE

<u>Vision</u> - The Old Testament Book of Proverbs says: Where there is no vision, the people perish ... In more recent times, Maslow wrote: The story of the human race is the story of people selling themselves short. Self-improvement guru Stephen Covey recommends that we begin with the end in mind. What is your vision of success?

Back in late 1996, we at the Idaho State Department of Agriculture set about to develop our vision of a successful noxious weed management program for which we have statutory responsibility. To do this, we relied on our 30-member Noxious Weed Advisory Council

whose mission is to provide assistance and advice to the Director for planning, coordinating and promoting weed management programs to benefit the people and resources of Idaho.

Our vision of success looks something like this:

All Idaho citizens are aware of the degrading impacts of noxious weeds on the environment and the economy and are willing to take responsibility for doing what they can.

Landowners are organized at the community level, on the basis of geographical areas or watersheds, into Cooperative Weed Management Areas (CWMA) directed by an active Steering Committee with broad citizen involvement, and a full-time coordinator.

The CWMA implements an Integrated Weed Management Plan that utilizes all the tools: careful use of selected herbicides; biological management agents; and employment of effective cultural, mechanical, and management practices. Detection and prevention (eradication) is the first line of defense. Restoration of potential invasion sites and weed-degraded lands is the ultimate goal.

The CWMA has an effective mapping and monitoring system in place: they know the location and extent of weeds in the watershed, their rates-of-spread, and the effectiveness of management measures. They are able to identify potential invaders and predict likely invasion sites.

The CWMA has the necessary partnerships in place to help blur jurisdictional and administrative lines and optimize use of available resources. Through these partnerships, outside dollars are leveraged.

They look for, and celebrate, SUCCESS!

Tall orders? You bet! It will come as no surprise that we are far from realizing our vision of success in Idaho. But we do have islands where local people are on the road to success. Perhaps our greatest need is to institutionalize this vision. We are holding the Governor's Idaho Weed Summit in Boise on May 19 & 20 to try to accomplish this.

Planning Whenever the need is greater than the available resources, it is paramount to have a PLAN that identifies priorities. Certainly the need is great: in Idaho we now have over 8 million acres dominated, or in the process of severe degradation, by noxious weeds: leafy spurge, spotted knapweed, yellow starthistle, meadow hawkweed, dyers woad, purple loosestrife, and rush skeletonweed to name a few. Others, such as Eurasian watermilfoil, are at our doors. We are surprised and disappointed to find how few counties and other jurisdictional areas, county, state, and federal have even a simple annual operating plan. This seems pretty fundamental to any program where tax dollars are expended.

Plans don't need to be long and complicated but they must identify what, where, when, how, and who. Otherwise, we will continue to be like the little Dutchboy trying to stop the flood by plugging the hole in the dike with our thumb. Things which matter most must never be at the mercy of things which matter least measure twice cut once . What we need though is not better documents, but better decisions.

Simplicity - It is said that Napoleon, as he went about his military campaigns, kept an aide, who was an idiot, on his field staff to review his battle plans. If this aide could not understand the objectives, troop movements and deployments, Napoleon would continue to simplify them until he could reasonably understand them. The Little General then felt assured that his plan of battle would have a reasonable chance of success.

Consider the Gettysburg address, the Declaration of Independence, or the Sermon on the Mount: powerful words to be sure. Compare this with the 2500 pages of the 1997 Federal Tax code. The point is that there is beauty in simplicity and some of the most effective weed management plans I have reviewed have not been an inch thick. Effective plans have clear objectives and concisely address the *who*, *where*, *what*, *when* and *how*.

Partnering Idaho, like many states in the West, is predominately federally owned and it is clear that weeds don't have any preference for land ownership. At the same time, the way we go about dealing with invasive weeds is somewhat different on private, state, county, and federally owned lands. Yet the biology, ecology, and economics of the business are the same. The more we can emphasize the similarities, and minimize the differences, the greater the chance for overall success. I personally know of no situations where weeds are successfully controlled or managed on one category of land ownership, to the exclusions of others. Quite the contrary, if one landowner works tirelessly to manage weeds, and the others do not, his efforts are usually in vain. So we must work together to succeed individually.

I cannot remember any issue or problem for which there was as much unanimity as to the need to work together to curb the onslaught of noxious weeds. There is absolutely no valid reason for each landowner to try to go-it on their own. My experience is that landowners and managers at the grass-roots level want to work together and they need only support, encouragement, and some resources from County Commissioners, and mid and top-level agency managers and administrators. In fact, the necessary formal agreements are usually in place but much remains to put into practice collaboration on the ground. If each agency or unit of government cannot afford a full-time coordinator, they should consider pooling resources to acquire one with watershed-wide or countywide responsibilities. This is done all the time with law enforcement.

In some rural areas, the federal agencies have a sizeable presence, perhaps a Bureau of Land Management Resource Area office or a Forest Service District Ranger office. Among this pool of specialists and resource managers is usually one or several who have good organizational abilities and can be the catalyst for initiating and organizing a truly collaborative grass-roots effort. Many times this person may have to be something of a shadow leader because of the initial suspicions about a federally led effort. Yet, if they

persist and are willing to let non-federal partners eventually assume the leadership roles, they will achieve high credibility and respect and these biases will fade. More importantly, talk will turn to action.

Persistence The noxious weed problem facing us did not come about in a fortnight. We should not expect it to be solved in a short time either. Anyone not in the game for the long haul should not be in the weed management business. I share the belief with many others, however, that there is not a more dangerous ecological, economic, and even social threat facing us than the unchecked spread of noxious weeds and other invasive species across our American landscape. Yet these weeds per se may not be our greatest enemy: perhaps indifference, lack of vision and creativity, discouragement, and failure to work together may be the greater threat to success. Remember that the greatest cure for worry is action.

This list of principles that I have discussed is certainly not a comprehensive one and there are others that are important in this business of organizing and empowering people to institutionalize effective weed management. From my experience, the best way to assure that these and other success principles translate into action is through the formation of **Cooperative Weed Management Areas (CWMA).** Following the recommendations of groups who have faced the same challenges and who have already had some success ought to give us greater confidence. It will also allow more time to focus on human aspects such as building relationships, trust, leadership and commitment rather than on the organizational aspects. At the same time, following the CWMA model(s) still allows for individuality, flexibility, and adaptability to meet the needs of the participants and their available resources. In Idaho, we currently have at least 6 Cooperative Weed Management Areas and each is unique in many ways. Others are in the works.

I hope to see the day when every watershed in Idaho is a part of one of these CWMA. In conclusion remember that real change rises up and that one man with courage is a majority Gen. Thomas J. (Stonewall) Jackson.

BLM Weed Page

National Weed Symposium

April 8-10, 1998

ABSTRACTS

CONCEPTUAL MODEL FOR EVALUATING THE ECONOMIC EFFICIENCY OF WEED MANAGEMENT PROGRAM ACTIVITIES

Ed Singleton, Bureau of Land Management, Vale, OR

A practical and effective conceptual computer model to analytically evaluate and display the economic benefits of weed management activities has been commissioned by the Bureau of Land Management and developed by Bighorn Information Systems of Costa Mesa, California. The conceptual model is based on the National Fire Management Analysis System (NFMAS) which is an operational system that has many attributes that are directly applicable to the weed management program. The conceptual model describes the benefits and disadvantages of local weed management activities including: detection of potential infestation including kinds and probability of detection; mitigation by "kind" of infestation, method of control, and probability of success; costs by method of detection and control, and degree of infestation; and loss based upon market and non-market resource outputs. There is a high probability that the concepts of the NFMAS model could be successfully applied in the development of a similar model for weed management with similar benefits for planning and budgeting.

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CONCEPTUAL MODEL FOR EVALUATING THE ECONOMIC EFFICIENCY OF WEED MANAGEMENT PROGRAM ACTIVITIES

Presented by Edwin J. Singleton
Bureau of Land Management

ABSTRACT

The Prolific spread of invasive weeds (also known as exotic, non-native, and noxious) is recognized by the Bureau of Land Management (BLM) researchers and partners as causing the greatest, most rapidly accelerating negative impact to the long-term health of the land today. Population estimates indicate that invasive weeds are increasing at an alarming rate of about 2,300 acres per day on BLM administered land alone.

While the need for control work on established infestations is usually clearly recognized, support for prevention and detection activities on uninfected areas is more difficult to secure. This tends to be especially true as funding becomes more constrained, and such activities are viewed as diverting money and resources from the more visibly needed (and thus perceived as *defacto* higher priority) control work.

Restoration/rehabilitation activities have not been adequately considered in the past in relation to the ability of a healthy ecosystem to resist the initial invasion or re-invasion of a site by invasive plant species.

Implicit in the discussion above is a lack of a formal process to evaluate an existing or potential weed infestation, and identify the relationships between potential economic losses and the cost and effectiveness of available mitigating program activities. The information from such an analysis provides managers, administrators, and legislators with insight into the probable benefit-cost of program alternatives, and can be used both to support budget proposals and to assist in prioritizing the expenditure of available funds.

A practical and effective conceptual computer model to analytically evaluate and display the economic benefits of weed management activities has been commissioned by the Bureau of Land Management and developed by Bighorn Information Systems of Costa Mesa, California. The conceptual model is based on the National Fire Management Analysis System (NFMAS) which is an operational system that has many attributes that are directly applicable to the weed management program. The conceptual model describes the benefits and disadvantages of local weed management activities including: detection of potential infestation including kinds and probability of detection; mitigation by "kind" of infestation, method of control, and probability of success; costs by method of detection and control, and degree of infestation; and loss based upon market and non-market resource outputs. There is a high probability that the concepts of the NFMAS model could be successfully applied in the development of a similar model for weed management with similar benefits for planning and budgeting.

PARTNERS AGAINST WEEDS IMPLEMENTATION STRATEGY: *Conceptual Model for Evaluating the Economic Efficiency of Weed Management Program Alternatives*

Statement of Purpose

A practical and effective model to analytically evaluate and display the long term economic benefits of integrated weed management activities must be developed for broad scale use and application.

The model describes the benefits and disadvantages of local integrated weed management activities including: prevention, detection, suppression/control and restoration/rehabilitation activities that are appropriate for both the risk of infestation and spread and the potential for adverse biological and economic impacts on the lands affected.

Invasive noxious weeds have been described as a raging biological wildfire--out of control and spreading rapidly. The devastation from these alien plants includes enormous economic losses to agriculture and irreparable ecological damage to wildlands. Millions of acres have been invaded or are at risk, including rangelands, forests, wilderness areas, national parks, recreation sites, and wildlife management areas. Wildfires and weeds share much in common, including impacts, spread and management.

IMPACT

Like an unwanted wildfire, noxious weeds can drastically affect wildland plant and animal communities, damage watersheds, increase soil erosion, and adversely impact recreation. However, unlike the temporary negative impacts of wildfire, ecological damage from extensive noxious weed infestations is often permanent. Lands affected by wildfire are self-healing, whereas lands invaded by noxious weeds don't return naturally to their pre-invasion condition. Weeds continue to spread and the damage worsens. When considering long-term ecological effects on the land, invasion by aggressive non-indigenous noxious weeds is far more damaging than any wildfire.

SPREAD

Weed infestations enlarge and spread much like wildfires, beginning small, then expanding to cover huge areas if not controlled quickly. Weed seeds, like embers, can be carried long distances by wind or other means. The resulting new "spot" infestations grow and merge, much like spot fires ahead of an advancing fire front.

MANAGEMENT

Modern wildfire management is based on elements of **Prevention, Detection, Suppression/Control,** and **Revegetation;** the same fundamentals of effective weed management. A balance of all four elements is essential for effective management of wildfires or weeds.

Prevention

Prevention is the first line of defense against wildfires, and the same should be true for noxious weeds. The old adage "an ounce of prevention is worth a pound of cure" applies perfectly to both. Weed prevention means placing a priority on preserving and protecting lands not presently infested.

Wildfire prevention depends on widespread public awareness and concern achieved through a balance of education and regulation. Fire prevention messages appear in a variety of forms and places to remind people of the critical role everyone plays in this effort. Regulations such as campfire restrictions contribute significantly to wildfire prevention.

Education and regulation are key ingredients needed to raise public awareness and gain greater support for weed prevention. More land managers and users need to recognize the adverse effects of noxious weeds and become involved in efforts to reduce spread. Informed hikers, campers, hunters, bikers, 4-wheelers, and other recreationists also could do much to prevent the spread of weeds. A significant portion of every weed management budget should be devoted to awareness education and to other forms of prevention.

Detection

Early detection of wildfires makes rapid and complete control much more likely. The same is true for weeds. Wildfire detection is the primary duty of assigned individuals, but all field personnel within land management agencies are expected to watch for and report wildfires. Weed detection requires field surveys and accurate mapping by designated weed management personnel. As with fire detection, other field personnel could be trained to recognize and report targeted noxious weeds. The public plays a significant role in fire detection and reporting. Ways should be explored to involve volunteer groups, recreationists, and other interested public land users in noxious weed detection and reporting.

Suppression/Control

The third element of weed and wildfire management is actual control. Wildfire control activity is called suppression. Fire fighters follow a proven step-wise process of (1) rapid response, (2) size-up, (3) containment, and (4) mop-up. Suppression efforts may fail if all four steps are not completed in proper sequence.

Adoption of similar four-step approach to noxious weed control could increase the effectiveness and efficiency of almost any weed program.

1. Rapid Response- Controlling wildfires when they are small reduces costs and minimizes resource losses. An initial attack fire crew usually is dispatched within minutes of a report, and control begins before most wildfires exceed 0.1 acre in size. In contrast, control of noxious weeds is often postponed until infestations have covered hundreds or thousands of acres and are beyond hope of eradication. Adopting a rapid response attitude about new noxious weed infestations is vital to success.

2. Size-up- Developing the best plan of attack against each new wildfire requires information on incident size, direction and rate of spread, location and value of threatened resources, and control constraints (terrain, accessibility, safety, method restrictions, budget, etc). Gathering and incorporating this information into a plan is called size-up, and must take place before control actions begin. Similar factors must be addressed when developing a weed control plan. Bypassing the size-up step in weed management is an invitation to inefficiency and possible failure.

3. Contain / Confine- The first objective in wildfire suppression is always containment--protecting unburned areas by stopping further spread. Efforts are focused on the fire's advancing perimeter, not on the core. If full containment is not practical, the goal is to stop spread on one or two sides to save the most valuable resources. Spot fires outside of a containment zone always receive highest control priority.

The same strategy should be applied to weed management--stop the advancing perimeter before controlling the interior of an extensive infestation. Sometimes weed managers may be tempted to direct most or all control efforts at the core of large weed problems, ignoring the need for perimeter containment and control of isolated spots. This approach is like dropping fire fighters into the center of a huge wildfire and ignoring the expanding fire front. Spread continues, as if nothing had been done.

4. Mop-up- The final step in fire suppression is called mop-up. It involves hours of tedious labor to find and extinguish every live ember inside a containment area. Until mop-up is completed, a fire is not considered controlled and may flare up and escape.

In weed control terms, mop-up means total eradication. It involves killing every weed and exhausting the soil of all seeds. Years of dedication and persistence are required. The effort needed for eradication may be justified only on relatively small patches or along containment edges of larger infestations. However, failure to fully mop up any weed infestation essentially guarantees its eventual re-establishment and spread.

REVEGETATION/RESTORATION

The fourth fundamental of wildfire management is revegetation. Often it occurs naturally, but other times it must be assisted. Weed managers also should place emphasis on revegetation following control, realizing the value of healthy desirable plants in protecting sites from re-invasion by noxious weeds.

A CONCEPTUAL MODEL

Essentially every aspect of wildfire management has close weed management parallels, making it an excellent example or pattern from which to develop more effective weed control strategies and programs. Thinking of weeds as a slow-moving wildfire can provide a valuable perspective when developing and implementing weed management plans.

In the fall of 1997, the Bureau of Land Management commissioned a conceptual model be developed by Bighorn Information Systems of Costa Mesa, California based on the National Fire Management Analysis System(NFMAS). Essentially every aspect of wildfire management has close weed management parallels, making it an excellent example or pattern from which to develop more effective weed control strategies and programs. Thinking of weeds as a slow-moving wildfire can provide a valuable perspective when developing and implementing weed management plans.

INTRODUCTION TO THE MODEL

An efficient and effective integrated weed management program requires the timely implementation of local prevention, detection, suppression/control and restoration/rehabilitation activities that are appropriate for both the risk of infestation and spread and the potential for adverse biological and economic impacts on the lands affected.

The *Partners Against Weeds* Action Plan (BLM, January 1996) details the need for such an integrated approach to the noxious weed problem. However, it also points out three significant difficulties that managers encounter in adequately planning, funding, and implementing these program activities:

- Since a weed infestation often builds in significance over a longer period of time, the potential eventual consequences (especially economic!) may not be evident or well understood in the earlier stages. Thus a sense of urgency for planning, financing, and implementing appropriate mitigating measures that would provide the most efficient course of action in the long run may be hard to generate.

- While the need for control work on established infestations is usually clearly recognized, support for prevention and detection activities on uninfected areas is more difficult to secure. This tends to be especially true as funding becomes more constrained, and such activities are viewed as diverting money and resources from the more visibly needed (and

thus perceived as *defacto* higher priority) control work.

- Restoration/rehabilitation activities have not been adequately considered in the past in relation to the ability of a healthy ecosystem to resist the initial invasion or re-invasion of a site by invasive plant species.

Implicit in the discussion above is a lack of a formal process to evaluate an existing or potential weed infestation, and identify the relationships between potential economic losses and the cost and effectiveness of available mitigating program activities. The information from such an analysis provides managers, administrators, and legislators with insight into the probable benefit-cost of program alternatives, and can be used both to support budget proposals and to assist in prioritizing the expenditure of available funds.

A parallel was noted in *Partners Against Weeds* between weed management and wildland fire management program activities. Both deal with events which spread in a reasonably predictable manner from localized "starts", and which require timely detection in order to activate an appropriate control/suppression response.

The Forest Service and Bureau of Land Management have used an analytical computer model (the National Fire Management Analysis System (NFMAS) to evaluate the efficiency of local fire program alternatives for more than 15 years. The outputs from the model have been used to plan local, regional and national fire programs and support budget requests, to assist in identifying priorities for the allocation of funds among administrative units, and to help managers with program implementation decisions.

The NFMAS Model

The National Fire Management Analysis System is designed to evaluate the efficiency of fire management programs. It uses a computer simulation model to estimate the probable effectiveness of local fire organization components and activities, and to identify the expected costs and the benefits, over time, of program alternatives.

NFMAS is by design a marginal change model. As such, it is most valid as an estimator of the differences in the cost and performance of program alternatives (that is, proposed programs with different kind, amount, timing, and/or location of program activity).

The NFMAS simulation model operates by evaluating the effectiveness of a proposed fire organization (with specific prevention, detection and suppression components) against the expected fire occurrence on the planning unit.

Conceptual Design Objectives

1. Simulate the activities associated with noxious weed prevention, detection, and suppression/control (mitigation).

An objective would be to relate model inputs and outputs to the local administrative planning unit such as the BLM District.

2. Evaluate the probable effectiveness of proposed weed management program activities against expected noxious weed infestations on the planning area. Effectiveness of a defined program activity would be evaluated in terms of how well the activity is likely to perform (prevent, detect, control) over time with respect to an infestation of a given kind, size, density, rate of spread, or other factor, in a particular vegetative, topographic, or climatic environment.

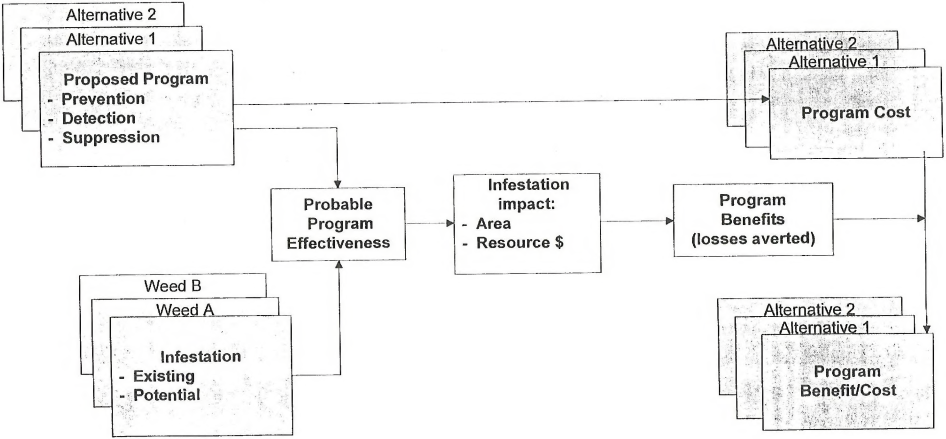
3. Track the costs of proposed weed management program activities by appropriate categories as required for agency program planning and budgeting.

4. Estimate the consequences for the planning area of weed infestations on planned resource outputs as they would be affected under a proposed weed management program alternative.

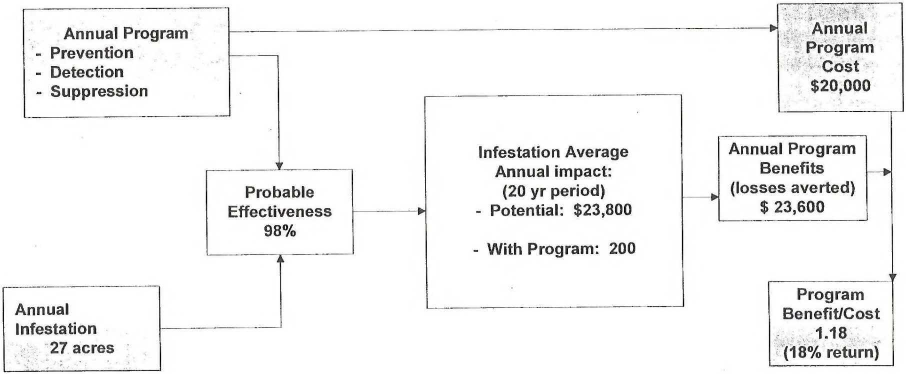
5. Provide outputs for each weed management program alternative evaluated in terms of the expected annual averages for numbers and acreage of infestations and resource losses for the planning area. Because weed infestations and related mitigating activities extend over periods of years (as opposed to wildfires which have a maximum life span of days), the effectiveness evaluation will encompass, and annual outputs will be produced for, a multi-year planning period.

6. Provide for each program alternative a present value total cost plus net resource value change by which the economics of all proposed alternatives can be compared.

Malheur Resource Area
Weed Management Program Analysis



Malheur Resource Area
Example Annual Program Analysis



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Summary of the symposium *"Science in Wildland Weed Management,"* Denver, Colorado, April 8-10, 1998

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During three days in April, 1998 a diverse and talented group of land managers, researchers, and other interested parties gathered to discuss the application of science in the prevention and control of exotic pest plants (weeds), and restoration of the native ecosystems they occupy. A vast amount of information was presented and the purpose of this article is to summarize that information and present an overview of the major issues that emerged from subsequent work groups and discussions. I provide a thumbnail sketch of each presentation, emphasizing the points that caught my attention. The length of a vignette in no way implies the significance of the presentation.

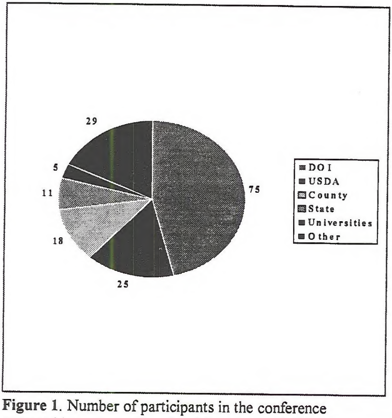

Figure 1. Number of participants in the conference arranged by major categories. The category "Other" includes non-government organizations, private industry representatives, conservation organizations, etc.

The meeting was attended by about 150 people (Figure 1). Most were from the Departments of the Interior and Agriculture. State and County agencies were relatively well represented. Researchers from universities were notably in the minority. Given the important research that some university faculty are conducting relative to invasive exotic plants, this is a group that should be sought out for future meetings. Significant bridges already exist between academia and land managers and include former Cooperative Wildlife Research Units, and Cooperative Park Study Units now under the administration of the U.S. Geological Survey, Biological Resources Division.

Presentations were grouped into three major sessions: one each on Prevention, Control, and Restoration. Most of the presentations were in the Prevention session; showing the importance of this strategy in the war on weeds. Control and Restoration received relatively equal attention.

The moderator for the opening session was John Randall of The Nature Conservancy who introduced the Secretary of the Interior Bruce Babbitt. The Secretary gave a call to action and noted a need to integrate our efforts nationally in the war against weeds. He also noted a need to be forthright and honest regarding the use of herbicides in the war.

Jerry Asher of the Bureau of Land Management (BLM), noted that the amount of land being restored is minuscule compared to the amount of land being degraded by exotic pest plants. Invasion of natural ecosystems by exotic plants is an ecological and economic emergency deserving as much attention as a wildfire. Nature can help extinguish wildfires, but not necessarily invasion by exotic pest plants. The good news was that some weeds are recent arrivals, and thus relatively easy to control, in comparison with long-established massive infestations of other species.

Pat Fosse, also of the BLM, related her experience working in Cooperative Weed Management Areas. She told the story of the spread of squarrose knapweed. Many meetings were held to discuss options for dealing with the invasion while the plant continued to spread. This reminded me of an incident that once happened to me. I was attending a meeting to discuss restoration of degraded desert habitat in the Barstow, California BLM office and informed my colleague, the dedicated Wildlife Biologist Tom Egan, that I would drop in to see him. Tom is part of a team of resource specialists removing saltcedar from the Afton Canyon Area of Critical Environmental Concern and replanting native willows and cottonwoods. The note I found on his desk said it all, "*Jeff, while you're in a meeting talking about weed control, I'm out doing weed control!*" Pat's story, and my experience, underscore the importance of action. Pat concluded by encouraging the group to preserve options for future generations who will inherit our public lands.

Steve Dewey of Utah State University continued the theme initiated by Pat Fosse by pointing out that anything that causes avoidable delays in weed control has serious consequences. He also encouraged resource managers to find and use existing knowledge on weed control and to support the development of new knowledge. Since information on weed control is rarely available for all weeds in all places managers must sometimes add local details to the otherwise broad strokes of research. Finally, he reminded us to consider untested observations on weed control as speculation, hearsay, or personal opinion.

Pat Shea, the Director of the BLM, kicked off the session on Prevention, chaired by George Beck of Colorado State University, noting that research is desperately needed that has direct application in the field. Basic research is obviously important, but managers need more tools to combat the threats posed by invasive species right now.

Peter Rice of the University of Montana contributed to the Session by showcasing his INVADERS Database. He demonstrated that it is generally too late for eradication or containment of an invasive exotic species after the exponential phase of population growth is attained. Many small infestations can actually spread to infest a greater area than a single large infestation. Managers are often focused on local issues, but need to think in larger scales to fight an integrated battle relative to weed control.

Cathy Calloway of the Forest Service gave the manager's perspective using the Invaders Database, successfully utilizing the system to evaluate a No Action Alternative for weed control, demonstrating its utility for evaluation under NEPA.

Henry Lachowski, also of the Forest Service provided a "clear overview" (pun intended) of remote sensing for mapping the location and spread of exotic invasive plant species. Leonard Lake, yet another Forest Service employee, demonstrated the limitations of remote sensing for detecting weeds from the standpoint of a manager.

The Control Session was moderated by Barbra Mullin of the Montana Department of Agriculture. Carolyn Sieg of the Forest Service lead off in the session by discussing weed population dynamics following a wildfire. She pointed out the wisdom of putting money into research and monitoring following fire, not just spending it on herbicide for weed control. In her study, burn severity was shown to have a big impact on weed density. She showed how carefully timed mowing and controlled burning can prevent seed set by some species of exotics. Also, fire management can be an important tool to reduce fuel loads, thus preventing the severe fires that many weeds like. Bill Baker of the BLM followed by discussing a managers perspective and experiences with post fire weed spread.

Peter Harris of the Agriculture Canada Research Center gave an overview of biocontrol successes, risks and research needs. Debra Eberts of the Bureau of Reclamation talked about her experience with biocontrol and showed how time consuming it can be to get some insects established in the field.

The Session on Restoration was chaired by Gary Johnston of the National Park Service. Roger Sheley of Montana State University talked about restoring susceptible lands and post weed-control restoration. He pointed out that revegetation comes at a high cost and the results are often unpredictable. He provided some ecological models based on niche theory for understanding the associations between native and exotic plants.

Larry Holzworth of the Natural Resources Conservation Service talked about restoration with native plants. Timing is everything and it is important to work with nature to give restoration projects the best chance of success.

Tom Whitson of the University of Wyoming spoke about establishing a sustainable vegetation ecosystem to replace noxious weeds. His efforts underscored the need to develop and bolster industries that supply restoration projects with native seed stock. The high cost of native seed (or their unavailability in some areas) complicates restoration projects. When used alone, herbicides may remove one weed and allow entry by another. Grasses can be used to out compete bromes and leafy spurge when used in conjunction with herbicides.

Cindy Owlsley of Boulder County Weed Management gave a manager's perspective with restoration and thanked the scientists in the audience because "Without them, we wouldn't know what we where doing."

The last session was on Organizational Strategies and Bill Brown of the Department of the Interior noted that there are no international treaties dealing with invasive species. He talked about development of a national invasive alien species council to deal with the issue of exotic species and the need for international cooperation.

Glen Secrist of the Idaho Department of Agriculture talked about fostering new Cooperative Weed Management Areas and suggested that we, as weed warriors, are not working half as smart as we could. Given that programs should not expect major future budget increases

to deal with the problem of invasive species our only alternative is to work smarter. An important theme he emphasized was the need for vision in the national war on weeds.

Ed Singleton of the BLM talked about the relationship between fire and weeds using a cost/benefit analysis. He compared weed invasion to a biological wildfire and noted that little money is spent on prevention of weed spread and rehabilitation of weedlands relative to money spent on fire suppression programs.

The Summary Session was again chaired by John Randall. After I presented the preceding summary of the program, Bertha Gillam of the Forest Service gave an inspiring set of closing remarks.

Major themes, issues, and observations

When it was all said and done I couldn't help but ask the question, what did we learn? Several points made during formal presentations or in breakout groups really caught my attention and they are highlighted below.

1) **Nature abhors a vacuum: weeds love them**. The bottom line is that if we remove or disturb something natural, something unnatural is likely to move in.

2) **An ounce of prevention is worth a pound of cure**. We spent a lot of time talking about prevention of new invasions, and for good reason. Dollar for dollar, there is no more cost effective weapon in the fight against exotic alien species.

3) **Land disturbance encourages invasion**. Whenever natural systems are disturbed or damaged the welcome mat is laid out for many invasive species.

4) **Weed removal without restoration is wasted effort**. Tom Whitson, in particular, demonstrated the folly of trying to eradicate exotics without working to re-establish more desirable (preferably native) vegetation. Another weed may just move in if nothing is done following removal efforts.

5) **Restoration is costly and has a low rate of success**. While restoration is desirable, it is not cheap, nor is it always successful. Restoration projects should budget for potential failure and have money set aside for revegetation in multiple years.

6) **The amount of land being restored is minuscule in relation to the amount being degraded**. This is a sobering reminder that it is far easier to damage or destroy healthy native ecosystems than it is to repair them.

7) **We do not want to be guilty of having too many meetings and not enough action**. Pat Fosse's presentation said it all: talk is cheap, action is not.

It is significant to highlight some of the issues that were not discussed at the Symposium. One missing topic concerned the political implications of weed control efforts. It is self-evident that one persons weed is another persons desired plant for a variety of reasons, whether it is

associated with horticulture, or more complex issues. One of the most recent conflicts is the controversy over whether to release insects for biocontrol of saltcedar, or not because of concern for various wildlife species who now make their home in saltcedar dominated riparian systems in the desert southwest. One such species is the federally endangered Southwestern Willow Flycatcher. Although the flycatcher once nested in dense groves of native desert riparian vegetation, these areas are now virtually replaced with saltcedar. The issue basically boils down to a conflict between those who want to protect an exotic plant-dominated ecosystem for the sake of a single species, or suite of desirable species, and those who argue for the return of a more natural ecosystem for the sake of all species. Additional information on the controversy can be found in a scientific publication reviewing the issues (Lovich and de Gouvenain, 1998) or by accessing various web links listed at

http://www.werc.usgs.gov/cc/lovich/htm

Another topic that was not discussed is related to the above: the impacts of exotic invasive plant species on wildlife and their habitat requirements. This is a very important topic and far more research is needed to assess these impacts.

What do we need to be successful in the "War on Weeds?"

During the presentations and breakout sessions several needs were identified by participants. They are not presented in any particular order.

1) **Strong leadership and vision**. The encouraging words of Secretary of the Interior Bruce Babbitt, Director of the BLM Pat Shea, and Director of Rangeland Management, Forest Service Bertha Gillam were welcomed by the group. We need their continued support if we are to achieve success in our efforts to stem the tide of invasive species.

2) **Resources to accomplish the task**. The war on weeds will be costly and will require a strong commitment to staffing.

3) **Incentives**. Some people suggested that resource managers should have an element in their annual performance plan that requires them to dedicate resources to prevention and control of exotic species, and restoration of degraded lands. Similarly, employees who achieve outstanding results in these areas should be rewarded appropriately and conspicuously.

4) **Research**. More research is needed on the effectiveness of control efforts and restoration. Although basic research is still desirable and needed, the field is clamoring for more applied research.

5) **Outreach**. There has never been a greater need for public outreach. The public may not recognize invasive exotic species or the threats they pose to our nations rich natural heritage. We must reach beyond "preaching to the choir."

In conclusion, the war on weeds will require a major effort at all levels; local, county, state and federal. We need committed and resourceful people dedicated to protecting and restoring our public and private lands from the threat posed by invasive exotic species. As General George Patton once said, "*Never tell people how to do things. Tell them what to do and they will surprise you with their ingenuity.*" That kind of ingenuity is needed now more than ever.

Literature cited

Lovich, J. E. and R. G. de Gouvenain. 1998. Saltcedar invasion in desert wetlands of the southwestern United States: ecological and political implications. *In*, S. K. Majumdar et al. (eds.). Ecology of Wetlands and Associated Systems. Pennsylvania Academy of Science. (*In press at time of this writing*).

SCIENCE IN WILDLAND
WEED MANAGEMENT

May 15, 1998

Dear Science in Wildland Weed Management Participant:

We were very pleased that you were able to participate in the "Science in Wildland Weed Management" symposium. Enclosed are several items that resulted from the symposium that we believe will be of benefit to all of the participants.

- 12 Action Items
- Categorized Priority Suggestions
- Participant List
- Proceedings

Feedback during and after the symposium indicated this was a special and information event, and we thank the many individuals and organizations who contributed to its success. Not only was it a valuable informational forum where many ideas were generated, but numerous collaborative actions will be taken to further the prevention and control of weeds on-the-ground. Thank you for contributing to this event – another vital step in continuing to bring together varied groups across the land who are interested and involved in weed management.

Again, we appreciate your interest and participation in this symposium.

Sincerely,

Carole 'Kniffy' Hamilton

Carole "Kniffy" Hamilton
Symposium Coordinator

4 Enclosures

"SCIENCE IN WILDLAND WEED MANAGEMENT" SYMPOSIUM

12 ACTION ITEMS

(This includes the four action items in each of the Symposium's themes of Prevention, Control, and Restoration as voted on by attendees)

RESTORATION	
TOP FOUR ACTION ITEMS	**PARTNERS**
On-the-Ground Application:	
1. Address noxious weeds in all EAs of all federal agencies.	**LEAD: Max Haegele, Bureau of Reclamation, FICMNEW** - John Mehlhoff, BLM
2. Increase native plant and seed production through incentive programs; i.e., tax breaks, benefits, cooperative production, assistance with funding, acreage, etc. Make native mulches, seed, and plant materials more readily available for revegetation projects and more affordable.	**LEAD: Gayle Turner, OSM** - Dennis Isaacson, OR Department of Ag - Jim Johansen, BLM (Boise Field Office)
Science Needs:	
1. Determine what assemblages of species can be used to most effectively manage weeds and how to deploy them.	**LEAD: Roger Sheley, Montana State University** - Pat Fosse, BLM (Fillmore Field Office) - George Beck, Colorado State University - Steve Dewey, Utah State University - Jim Young, ARS Unit in Reno, NV
2. Develop techniques to enhance native seed production, re-establish native communities, and to provide weed-free seed, affordable native seed, and rapid seed testing.	**LEAD: Larry Holzworth, NRCS** - Dennis Isaacson, OR Department of Ag - Peggy Olwell, Native Plant Conservation Initiative

"SCIENCE IN WILDLAND WEED MANAGEMENT" SYMPOSIUM

12 ACTION ITEMS

(This includes the four action items in each of the Symposium's themes of Prevention, Control, and Restoration as voted on by attendees)

PREVENTION	
TOP FOUR ACTION ITEMS	**PARTNERS**
On-the-Ground Application: 1. Develop an educational program aimed at engaging public land user groups, volunteer sources, and those who teach others using regionally specific weed ID and weed impact information.	 **LEAD: Mary Tisdale, BLM, Partners for Resource Education (interagency education group)** - Susan Johnson, Forest Service - Gary Johnston, FICMNEW
2. Develop a national mascot for weeds -- marketing strategy similar to Smoky Bear.	**LEAD: Steve Dewey, Utah State University** - Susan Johnson, Forest Service - Rita Beard, Forest Service - Kimberly Anderson, Forest Service
Science Needs: 1. Enhance Invader Data Base (GIS, etc.)	 **LEAD: Peter Rice, University of Montana** - USGS-BRD - Nate Dechoretz, WWCC - Jim Olivarez, Forest Service
2. Develop a manager friendly model to predict ecosystems that are vulnerable to invasion based on individual species biology and site characteristics (e.g., cheatgrass).	**LEAD: Jayne Belnap, USGS-FRESC (Forest and Rangeland Ecosystem Science Center)** - Mike Pellant, BLM - Jim Olivarez, Forest Service

"SCIENCE IN WILDLAND WEED MANAGEMENT" SYMPOSIUM

12 ACTION ITEMS

(This includes the four action items in each of the Symposium's themes of Prevention, Control, and Restoration as voted on by attendees)

CONTROL	
TOP FOUR ACTION ITEMS	**PARTNERS**
On-the-Ground Application:	
1. Structure public funding for weed control differently; i.e., fire model, not just rangeland budgets, provide incentives for effective prioritized management, develop strategic plans for competitive funding, allow for multi-year funding.	**LEAD: Gordon Brown, FWS, Interagency Task Force for Alien Invasive Species** - FICMNEW - INWAC - Ed Singleton, BLM
2. Require timely post wildfire weed detection surveys so that, if necessary, prompt weed control can occur before weeds set seed, and authorize Emergency Fire Rehabilitation funds for the surveys and control.	**LEAD: Jerry Asher, BLM (Oregon State Office)** - Secretaries of Interior and Agriculture - Deb Hayes, Forest Service - Colin Voigt, BLM - Irv Gaser, National Park Service
Science Needs:	
1. Develop, evaluate, monitor, and report management techniques to provide long-term ecosystem health and resistance to weed invasion.	**LEAD: Roger Sheley, Montana State University, Center for Ecologically- Based Weed Management** - USGS-FRESC - Andy Kratz, Forest Service
2. More research on biocontrol of organisms and focus research that is useful for application purposes.	**LEAD: Ernest Delfosse, ARS** - Ray Carruthers, ARS - Hank McNeel, BLM - Debra Eberts, Bureau of Reclamation - George Markin, Forest Service

SCIENCE IN WILDLAND WEED MANAGEMENT SYMPOSIUM
DENVER, COLORADO - APRIL 8-10, 1998

CATEGORIZED PRIORITY SUGGESTIONS FROM BREAKOUT GROUPS

In this document, the priority suggestions (top 3 science, top 3 on-the-ground application) from all the Prevention, Control, and Restoration breakout groups have been categorized into 6 groups: Education, Fire, Funding, Native Species, Management, and Research.

Please note the topics in bold-face lettering are the twelve action items resulting from the symposium.

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EDUCATION
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PREVENTION:

- **Develop a comprehensive information system of what we know summarizing current knowledge, along with a manager-friendly model to predict ecosystems that are vulnerable to invasion based on individual species biology and site characteristics; e.g., cheatgrass. (Jayne Belnap, USGS-FRESC (Forest and Rangeland Ecosystem Science Center), BLM)**

- Make literature more readily available and provide a link between data gaps.

- **Expand the INVADERS data base to include more species and states/areas where noxious weeds/invasives are concerned in the areas of high risk, rates of spread, and predictive parameters. Additions to the data base should be easy to make by users. (Dick Reardon, Dave Koehler, Peter Rice, USGS-BRD, Nate Dechoretz, WWCC.**

- Publish a book on biology of rangeland weeds to be used as a field guide.

- Create a centralized internet site on existing research programs, a data base for contacts with a search capability. (Chuck Wassinger)

- Increase education of travelers on how weeds get started.

- **National mascot for weed and fire prevention, a dual role. A marketing strategy similar to "Smoky the Bear" possibly designed after the fire/weed model. It would target youth education, provide for better marketing, and appeal to professional groups. (Steve Dewey, Utah State University; Rita Beard, Forest Service; Kimberly Anderson, Forest Service; Susan Johnson, Forest Service**

- Develop criteria for youth education and scouting weed badge including 4-H, K-12, FFA, Scouts, etc.

- Provide more public information on weeds.

- **Develop an education program aimed at engaging public land user groups, volunteer sources, and those who teach others using regionally-specific weed ID and weed impact information. For example, SWAT Team to work together to fight weeds. (Mary Tisdale, BLM, Interagency Education Group; Susan Johnson, Forest Service; Tamara Naumann, Forest Service, FICMNEW)**

CONTROL:

- Develop principles and concepts on which we base our weed management rather than provide prescriptions for control.

- Require IWM as component of courses for all land managers and natural resource students. (Robert Walton)
  PARTNERS: Phoenix Training Center, universities, technical schools

- Design a data base on the internet, a library of information and contacts (people) indexed by species - a curator for each species - links to literature.
  PARTNERS: WSSA

- Coordinate a strong planning effort in monitoring adaptive management, and design management as an educational tool like that of the Canadians. (Richard Krebill)

- Develop policy and educational programs to institute weed-free programs that encompass both commercial (seed company) and non-commercial programs such as re-seeding federal lands (all).

- Provide easy accessibility of books, CD Rom, etc., IPM strategies for managers keyed to specific ecosystems (wetlands, rangelands, etc.).

- Promote awareness/visibility: posters on roadsides, wanted posters in town, posters for education, demo plots, 1-800 hotlines to report weeds, postcards at trailheads with maps, and buy weeds by the pound (bounty reward).

RESTORATION:

- Develop a network of restoration demonstration areas for researcher, management, public education, training, including field tours.
  PARTNERS: Budweiser, extension service, chemical companies, local weed partnerships, SER/SRM/HAR, local media, conservation groups, public service companies/industries, highway department, public/private land managers.

- Develop interagency manuals and training to insure consistency among acceptable plant species lists and insure agency employees and other stakeholders understand weed impacts. (William Moody, Scott Hennessy)

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FIRE

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PREVENTION:

- No topics.

CONTROL:

- Obtain the authorization of post-fire weed detection and control with fire suppression funds and make noxious weeds mandatory in fire rehabilitation plans.

- The weed programs need to be elevated to a protection program such as fire with a line-item budget, and follow budget guidelines in Section 15 of NWC Law.

- There is a need for a fully-funded fire/weed economic analysis model. (Ed Singleton)

- **Require timely post-wildfire weed detection surveys so that, if necessary, prompt weed control can occur before weeds set seed, and authorize Emergency Fire Rehabilitation Funds for the surveys and control. (Jerry Asher, BLM; Secretaries of Interior and Agriculture)**

RESTORATION:

- Research the effects that fire has on weeds to include prescribed wildfire and in combination with herbicides. (Roger Inman)

- Develop new techniques to create fire brakes that don't support undesirable species and stabilize soil.
  PARTNERS: local and state government, fire-fighting community, universities, extension, NRCS/FS/BLM/BIA/ARS/BOR

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FUNDING

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PREVENTION:

- No topics.

CONTROL:

- There is a need to be creative in the funding processes, similar to that of the Montana Weed Tax Fund. (Max Haegele)

- There is a need for support at the state and local levels in all states to institutionalize and create legal mandates which will include funding for weed management.

- **Structure public funding for weed control differently than the current: model after fire funding, not tied to rangeland budgets, provide incentives for effective prioritized management (treating small outbreaks, bounties for early detection), develop strategic plans for competitive funding, and allow for multi-year funding. (Gordon Brown, FWS, Interagency Task Force for Alien Invasive Species, FICMNEW, INWAC)**

- Extend integration, pool all resources based on priorities on "all" lands. Remove boundary lines; i.e., take federal dollars, use on private lands.

RESTORATION:

- Show cost-benefits of rehabing rather than spraying every year, designate funds to implement demonstration areas. Pick the toughest spot because we need ongoing application and technology at the local level. National priority in funding cooperative within land managers, universities, and landowners.

- Develop a regulatory and funding process to mandate establishment and maintenance of noxious weed-free vegetative cover (and provides erosion and dust control). Includes: undeveloped land, ranchettes, roads, construction, abandoned land and water rights, and urban interface.

- Integrate restorative costs within all construction budgets. Include costs for ultimate restoration after project is no longer utilized. (Peter Rice)

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NATIVE SPECIES

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PREVENTION:

- No topics.

CONTROL:

- Develop, evaluate, and monitor management techniques to provide long-term ecosystem health and resistance to weed invasion; i.e., native and non-native and mixtures, and site alteration of soils, amendments, etc. (Larry Holzworth, Jayne Belnap, Hank McNeel)

RESTORATION:

- **Increase native plant and seed production through incentive programs; i.e., tax breaks, benefits, cooperative production, assistance with funding, acreage, etc. Make native mulches, seed, and plant materials more readily available for revegetation projects and more affordable. (Gayle Turner, OSM; Dennis Isaacson, Oregon Department of Ag**

- **Determine what assemblages of species can be used to most effectively manage weeds and how to deploy them. (Pat Fosse, BLM; Roger Sheley, Montana State University-Bozeman; George Beck, Colorado State University; Steve Dewey, Utah State University; Jim Young, ARS Unit in Reno, NV**

- Research successful restorative techniques to include more about native species, also which cannot be fenced, shrubs, and timespans. (Bernard Weynand)

- Improve propagation of native plants to lower costs, increase availability, improve techniques for successful establishment, and improve viability.

- A need for more research to be conducted on how to use early successional natives.

- **Develop techniques to enhance native seed production, re-establish native communities, provide weed-free seed, affordable native seed, and rapid seed testing. (Cathy Calloway, Forest Service; Larry Holzworth, NRCS; Dennis Isaacson, Oregon Department of Ag; Peggy Olwell, Native Plant Conservation Initiative**

- Work with local growers to provide native seed sources for restoration.

- Explore and select herbicide tolerant native species to feed to livestock and wildlife.
  PARTNERS: BLM, NRCS, industry, universities

- Study the use of livestock for reseeding with selected natives by feeding them native hay/seed prior to turnout - especially in remote areas.
  PARTNERS: agencies, universities

- Support additional trials of native plant species to identify successful competitors with noxious weeds and also develop methods for their re-establishment.

- Research methods for manipulating succession from mid-seral to desired plant community (remnants of natives and islands of native species).

- Establish a history of native plants from areas in which they originated; for example, where did willow originally come from? (Richard Sargent)

- Warehouse bulk amounts of native species seeds to provide enough seed on demand.

- Provide local sources of native plant species by growing own seed nurseries. PARTNERS: agencies/seed companies

- Use introduced cover crops to protect areas while re-establishing natives. Consider what the land is managed for. Consider goals for landscape. Interim strip between control and restoration.

- Establish interagency multi-year guaranteed purchase contracts for native seed and permanent regional storage and distribution centers.

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MANAGEMENT

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PREVENTION:

- Risk analysis in managing weeds; ecosystem, screening, decision support. (Jayne Belnap)

- What management tools do we have to prevent individual species. (Bill Baker)

- Develop regional/state level early warning lists updated annually for managers. (Cathy Calloway, Forest Service)

- Data that can be quantified regarding economic losses to various resource and private land values due to weeds. (Karen Crass, Public Lands Council)

- Develop real partnerships at local level between land management agencies, ARS, universities, etc.

- Encourage groups like North American Weed Management Association as the lead to facilitate prevention topics.

- Best management practices need to be standardized and institutionalized.

- Advanced planning to be prepared for timely response. (Application of risk assessment, including planning for national disaster.) (Jean)

- Develop Director's comprehensive communication plan. Interagency, MOU's.

- Clearinghouse for information easily accessible to managers, staff, schools, landowners, etc. Nationwide/Internet.
  PARTNERS: FICMNEW (John Mehlhoff)

- Formal network, consistent from state to state involving all partners and agencies to work together on prevention (information sharing).

- Infrastructure to enforce regulations (interstate and intrastate).

- Peer review assessment.
- Review of regulations and sampling.
- Form structured partnerships for information consolidation and dissemination. (Michelle Chavez)
- Emphasize the need to incorporate scientific practices into resource management. (Jayne Belnap)
- Regulatory policies need development. (Larry Klock, Forest Service; Hank McNeel, BLM)
- Develop urban weeds strategy to include public planning, construction, zoning. (Russell Johnson)

CONTROL:

- **Develop, evaluate, monitor, and report management techniques to provide long-term ecosystem health and resistance to weed invasion. (Roger Sheley, Montana State University-Bozeman, Center for Ecologically-Based Weed Management; USGS-FRESC; Forest Service)**
- Establish thresholds for weed populations. How much will we accept? (John Larson)
- Study soil/plant chemistry (allelopathy) and microflora (mycorrahizae) as a means of controlling introduced weeds.
- Study of natural barriers to proliferation of those noxious weeds in their natural ecosystem.
- Move research into using existing tools in combination for greater effectiveness; i.e., bio and herbicides. (Pat)
- Study consequences of no control of large-scale infestation - ecological changes and economic impacts.
- Triage/target areas/species; develop means to identify what areas/species, where efforts will be most successful, and which are more critical. (Jayne Belnap)
- Need better control on plant/seed importation.
- Control science. Show ecological advantage of "control" other than esoteric purposes. (Jeff Lovich)
- Weed management has to be integrated within other programs in land management; including funding, staffing, priorities, and program management.
- More research/demonstration areas for viewing/study in a multi-state approach.

- Provide resources to allow weed scientists/extension services more time to demonstrate current technology/knowledge to field managers. (Cindy Owsley)

- Simplify weed-free hay laws/certification - cooperation and standardization among states, incentive to expand the program. (John Mehlhoff)
  PARTNERS: State AG Departments, marketing/economics groups, counties, NAWMA

- Review biocontrol regulations to remove those not supported by scientific and/or are counterproductive.

- Empower ecoregional and local partnerships to recommend changes to regulations and policies.

- Incentives and regulations to support cultural/preventive measures; e.g., access management, weed-free before entry of livestock.

- Consistent ways to prioritize treatment areas. (Pat Fosse)

- Control tool (guide) to access type of species and how to manage species (BMP's) - CD Rom, hot links, interactive. Also include cost and risk benefit analysis for methods being utilized with periodic reviews of BMP's. (Jim, Pat, Angela, and Nate)

- Develop or modify existing guidance of inventory and long-term management for pipeline, oil and gas, rights-of-way, transportation plans to involve weeds. (Hank)

- More use of strategies which incorporate livestock grazing (sheep, etc.) into weed management and use of proper timing with livestock.

- Need total community partnerships. Use Pat Fosse Model - Squarrose Knapweed Demo WMA.

- Enforcement of statutes on national policies and regulations on noxious weeds so everyone will take care of weeds,

- Adaptive management techniques to address IPM: monitoring/assessment; what's wrong, what's right?

- Develop regional/ecosystems prioritization process for research and control efforts. (Bernard Weynand)

- Establish coordination meetings with five teams on policies/procedures and coordinate research and funding. (Deborah Hayes)

RESTORATION:

- Bridge the gap between land managers and academia to access the information. Use resources

such as USGS, cooperative agreements, cooperative research units, IPAs, etc. Land managers go out to universities and corporations. (Jeff Lovich)

- Show that restoration can reach your "ecological" goal. (Jeff Lovich)

- Explore further the "single-pass concept."
  PARTNERS: Universities

- Provide guidelines on when restoration is necessary or not - may not need all-out restoration in some areas, may just need some supplemental help.

- Library/control of literature of everything that has been researched in/on a central location.

- Research to define thresholds and what to do after threshold is exceeded. (Richard Krebill)

- Start restoration before industry has passed threshold (prioritize control efforts based on ability of area to reestablish itself after treatment). (Pat)

- Utilize a strong planning decision process that includes multi-scale (watershed need) and closely define objectives. (Richard Krebill)

- All partners should be considered (tribal, etc.). (Richard Sargent)

- Certification of all revegetation systems. (Angela)

- Identify historical management factors and site conditions that influenced vegetation community before planning revegetation techniques.

- More demonstrations of successful revegetation techniques.

- **Expand standards and guidelines for all agencies to adopt. Make them part of all environmental assessments. (John Mehlhoff, BLM; Max Haegele, BOR; FICMNEW)**

- Electronic data base that summarized scientific studies in weed field, with references. (Mike Holbert)

- Private and public landowner incentives for keeping their weeds controlled → mitigation. (Karen Crass, Public Lands Council)
  PARTNERS: state, county (tax breaks), federal agencies

- Local level key to coordination. National Association of Counties, County Board of Supervisors, Governor's need to demand to see proactive efforts from federal land management. (Jeff Lovich)

- A Secretarial Order mandating timely restoration and noxious weed control of agency land disturbances.

- Monitoring restorative efforts.

- Stop using invasive exotics for revegetation unless there is a good reason to use them.

- Follow agency requirements to sample and test seed before use in restoration. (Also redundant testing at local field level.)

- Privatize restoration work including monitoring, reseeding, equipment, labor, etc.

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RESEARCH

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PREVENTION:

- Develop soil restoration techniques.

- A need to have the ability to define/locate small initial populations; need rapid development of technology.

- Refine/develop predictive ability for potential distribution of invaders habitat (or areas where they are not able to grow).

- Research into seed mixes that are highly competitive against weeds, not necessarily the best forage. Develop cool season grasses for revegetating rights-of-ways that are less palatable. (Lee Otteni)

- Research techniques to manage disturbed areas to encourage desired vegetation that will out compete weeds. (John Larson)

- Expand remote sensing to target small infestations (20 species).

- Expand economic research with focus on urban/suburban interface impacts, effects (flower garden to ecological problem).

- National Center for Biological Pollution Control. (Roy Reichenbach)

- Develop protocol for seed industry to determine likelihood of spp. becoming noxious. Look at possible characteristics about communities that make them more resistant to invasion.

- Early detection. Deal with small outbreaks immediately. Interagency Swat Team.

CONTROL:

- **More research on biocontrol of organisms and focus research that is useful for application purposes; i.e., mustard species and medusahead. (Ernest Delfosse, ARS; Ray Carruthers, ARS)**

- Genetic engineering to disrupt growth/reproductive processes in weeds. (Robert Walton) PARTNERS: ARS, private industry, universities

- More research on biocontrol of organisms (focused research that is useful for application purposes). Establish system for collection of failures and successes for control anecdotal methods including non-target effects. (Angela)

- Find positives for weeds: genetically engineered, medicinal, fuels, and others. (Michelle Chavez)

- More research into the results/effects of not treating weeds as it relates to T&E species.

- Know the enemy in its new and old range. Need basic synecology and autoecology.

- Cross-breeding needs for sterilization of seed. Augmentation biocontrol is needed to increase opportunity for mutagen and seed sterility.

- Partnerships with chemical companies cooperative research and development agreements (CRDA's). More research on endemic micro-organisms to combat weeds versus exotic insects--find microbes that are here already that would attack weeds.

- Research combination of multiple management techniques; i.e., use of insects with spraying. (Cindy Owsley)

- Develop research studies that deal with rights-of-way and roadside weed control using a variety of techniques.

- Scientific/mathematical modeling to set minimum control objectives per species. What percent of population must be controlled to contain it? Objective is to arrest expansion, get ahead of the curve. (Gary Brannon, Eric)

- Methodologies for setting priorities for which species to control based on which will cost most if ignored; i.e., Rocky Mountain National Park Study. (Jeff Cohnner)

- Develop simple, statistically valid monitoring methods.

- Subsidize creatively the use of sheep/goats as weed control agents. (Roger Inman)

- Research competitiveness of desired restorative species at various density of control of non-desired weeds. (Deb Palmquist)

- Through literature searches and experimentation evaluate different restoration techniques (initial and follow-up treatments) for major habitat types and plant species; including (but not limited to) soil amendments (soil chemistry); timing, types, sources of seeds; mowing; fire; plowing; tilling; chaining; etc., aerial seeding; and grazing. PARTNERS: Science - USGS, SER, NRCS/ARS (federal research agencies), academics, SRM.
  PARTNERS: Management - All land management agencies

- Develop revegetation techniques for rough lands - steep, rocky, inaccessible terrain.

- Studies to match specific grass species with specific sites and weeds.

- Coordinate regional research (recognizing what works in one area may not work in another).
  PARTNERS: weed management area groups, granting agencies, researchers

- Determine what competitive assemblages of species can be used to most effectively control the spread and suppress and restore existing infestations of weeds and how and when to plant (include current information; i.e., literature search, etc.). (Pat Fosse)

RESTORATION:

- No topics.

SCIENCE IN WILDLAND WEED MANAGEMENT

SCIENCE IN WILDLAND WEED MANAGEMENT SYMPOSIUM
April 8-10, 1998
Holiday Inn Denver Southeast

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